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CATALOG OF GALACTIC β CEPHEI STARS

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ABSTRACT

We present an extensive and up-to-date catalog of Galactic β Cephei stars. This catalog is intended to give a comprehensive overview of observational characteristics of all known β Cephei stars, covering information until 2004 June. Ninety-three stars could be confirmed to be β Cephei stars. We use data from more than 250 papers published over the last nearly 100 years, and we provide over 45 notes on individual stars. For some stars we reanalyzed published data or conducted our own analyses. Sixty-one stars were rejected from the final β Cephei list, and 77 stars are suspected to be β Cephei stars. A list of critically selected pulsation frequencies for confirmed β Cephei stars is also presented.

We analyze the β Cephei stars as a group, such as the distributions of their spectral types, projected rotational velocities, radial velocities, pulsation periods, and Galactic coordinates. We confirm that the majority of the β Cephei stars are multiperiodic pulsators. We show that, besides two exceptions, the β Cephei stars with high pulsation amplitudes are slow rotators. Those higher amplitude stars have angular rotational velocities in the same range as the high-amplitude δ Scuti stars ($P_{\rm rot} \gtrsim 3$ days).

We construct a theoretical HR diagram that suggests that almost all 93 β Cephei stars are main-sequence objects. We discuss the observational boundaries of β Cephei pulsation and the physical parameters of the stars. We corroborate that the excited pulsation modes are near to the radial fundamental mode in frequency and we show that the mass distribution of the stars peaks at 12 $M_\odot$. We point out that the theoretical instability strip of the β Cephei stars is filled neither at the cool nor at the hot end and attempt to explain this observation.

Subject headings: Hertzsprung-Russell diagram — stars: early-type — stars: fundamental parameters — stars: interiors — stars: oscillations — stars: variables: other

Online material: color figure, machine-readable tables

1. INTRODUCTION

The past decade has seen many profound advances in our understanding of β Cephei stars. The discovery of the κ-mechanism driving the pulsation of these stars (Moskalik & Dziembowski 1992; Dziembowski & Pamyatnykh 1993) and the organization of many high-profile observing campaigns can be seen as recent highlights, and research into the physical properties of the β Cephei stars has flourished in response. The number of known β Cephei pulsators increases constantly, and recent years have seen us make several improvements to the way in which we discriminate between the many types of variable B-type stars. The exact definition of β Cephei stars has itself been strongly debated over the years, and there is a good deal of ambiguity in most definitions. The recent advances in our understanding of β Cepheids demand that a new refined definition be developed and that a new β Cepheid catalog be constructed and refined in line with this, examining and reclassifying all stars that have been previously identified or proposed as β Cephei stars.

In recent years, two reviews on β Cephei stars were published, describing the known group members from photometric and spectroscopic viewpoints, respectively. Sterken & Jerzykiewicz (1993) published a review of all then-known β Cephei stars including an extensive observational review of their astrophysical properties, and providing constraints on many of their key parameters. At the time, 59 β Cephei stars had been identified. The following decade saw the identification of more than 40 new variables of this kind, bringing the total to almost 100, although the exact population has not been cataloged since the original 1993 review. In response to these new identifications, a complementary review paper was published investigating the spectral properties of bright β Cephei stars that had detectable line profile variations (Aerts & De Cat 2003). Twenty-six objects could be examined in this way, allowing a better description of their physical properties and summarizing their pulsational behavior.

An excellent overview over β Cephei and Slowly Pulsating B stars for which Geneva photometry is available is given by De Cat (2002) in the form of an online catalog.[2] It provides the values of the Geneva indices as well as an homogeneous determination of stellar parameters based on calibrations of the Geneva system. This extensive compilation was one of the starting points for the present catalog.

Recent work has even demonstrated the presence of β Cephei stars outside our own Galaxy (Pigulski & Kołaczkowski 2002; Kołaczkowski et al. 2004b) providing data for investigating this type of pulsation in objects of different metallicity (see § 4).

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[2] See http://www.ster.kuleuven.ac.be/~peter/Bstars/.

All of these achievements originated from ground-based observations. Today, at the dawn of the 21st century, asteroseismologists are preparing to investigate variable stars from space, which will lead to the detection of many more excited pulsation modes in these stars. The first step in this direction was taken rather accidentally with the star camera of the *WIRE* satellite (Buzasi et al. 2000) after the failure of its primary science instrument. The first dedicated asteroseismology satellite, Canada's *MOST* (Matthews et al. 2000; Walker et al. 2003), was launched successfully in 2003 June and is returning valuable data on variable stars. Several other satellites investigating stellar pulsation will soon follow.

In this paper, we attempt to refine our understanding of β Cephei stars by cataloging the physical and pulsation properties of the entire confirmed population. This provides a comprehensive observational framework within which newly detected short-period pulsating stars can be classified. It will also be an aid for the classification of the vast amount of new pulsating stars that will be discovered in the near future. Using this observational framework, we reevaluate the membership of every object that was once classified as, or suspected to be, a β Cephei star.

Section 2 of this paper provides a brief description of the historical classification of β Cephei stars including information on asteroseismic space missions. In § 3 we describe different groups of variable stars of spectral type B, from which we derive our working definition of β Cephei stars. Section 4 lists the properties that have been examined for each of the stars in the catalog, explaining our reasoning behind their use. Section 5 provides detailed analyses of the entire data set from which we construct the observational framework, which in turn is later used to aid the identification of β Cephei stars.

In § 6 we discuss the observational boundaries of β Cephei pulsation. The conclusions and a definition of the β Cephei stars are presented in § 7. Tables of confirmed, candidate, and rejected β Cephei stars can be found in § 8 together with supplementary information on many of the objects. There we also give lists of pulsational frequencies for all confirmed β Cephei stars.

2. A BRIEF ASTROPHYSICAL HISTORY OF β CEPHEI STARS

The β Cephei pulsators have been known to the astronomy community for more than 100 years. The variability of the prototype of this class of variable stars, β Cephei, was discovered by Frost (1902). A spectral analysis led him to the conclusion that this star "is one of the Orion type . . . , of which group the typical star is β Canis Majoris." As a result, he named this group of stars the β Canis Majoris stars. At that time, the period of β Cephei could not be determined with certainty. Some years later, the first radial velocity curve for this star was published by Frost (1906). Guthnick (1913) discovered light variations of β Cephei with the same period as the radial velocity variations, and it was also noted that the amplitude of the latter was not constant (e.g., Henroteau 1918). The correct interpretation for this phenomenon was found by Ledoux (1951), who suggested that nonradial pulsations are present in some β Canis Majoris stars.

This group of stars comprised a rather wide range of variable B type stars and for many decades, at least up until the 1980s, these stars were known as β Canis Majoris or β Cephei stars. This redundant naming appears to have caused confusion among some authors. In, e.g., the *Hipparcos* catalog (ESA 1997), several stars are claimed to be classified as β Cephei stars for the first time, but were actually already classified as such under their previous name of β Canis Majoris stars.

Smith (1977) discovered that some of these β Canis Majoris stars were spectroscopic variables, and he called them the 53 Per stars. The term Slowly Pulsating B (SPB) stars was introduced by Waelkens (1991) for photometric B type variables pulsating in high radial order g-modes (gravity modes) with periods in the order of days. The 53 Per and SPB stars contain stars that are pulsating with periods longer than the fundamental radial mode and both groups have several members in common. The separation between β Cephei and SPB stars is a logical one based upon the physical fact that the first group pulsates mainly in p-modes (acoustic modes) of low radial order and the second in g-modes of high radial order. This implies that their pulsational driving mechanisms operate in zones of different thermal timescale. The β Cephei stars usually have one or more periods similar to that of the fundamental radial mode or the first nonradial p-mode (Lesh & Aizenman 1978).

In their extensive review paper, Lesh & Aizenman (1978) defined the class of β Cephei stars for the first time: "*These stars have the same short period for their light variation and radial velocity variation.*"

The pulsational driving mechanism for the β Cephei stars was unknown for a long time. After a revision of the metal opacities (Iglesias et al. 1987), Moskalik & Dziembowski (1992) were able to compute models for β Cephei stars in which the fundamental radial mode became pulsationally unstable for metallicities $Z > 0.03$. They found that the size of the theoretical instability strip for these stars depends on the abundance of heavy elements and that the pulsation mechanism prefers low-frequency oscillations. Only modes with a pulsation constant $Q > 0.032$ became unstable in these models. Furthermore, Moskalik & Dziembowski (1992) found that the theoretical instability region is larger than the β Cephei region in the HRD and that the same pulsation mechanism could be present in luminous blue variables (LBVs). Ninety years after the first discovery of the pulsation of β Cephei, models could be calculated where β Cephei type pulsation was driven.

Refined computations by Dziembowski & Pamyatnykh (1993) and Gautschy & Saio (1993) showed that pulsational instability could be reached for models with $Z > 0.02$. Instability was no longer restricted to the fundamental mode, but overtones were predicted to be pulsationally unstable as well. The current theoretical knowledge on the driving of β Cephei pulsations has been summarized by Pamyatnykh (1999).

Many β Cephei stars have been discovered to oscillate in several different pulsation modes (e.g., see Jerzykiewicz 1978). This opens the possibility to explore the interior structure of these stars by using asteroseismology, i.e., deciphering their pulsational mode spectra and modeling them theoretically. Examples can be found in, e.g., Dziembowski & Jerzykiewicz (1996,1999). Indeed, Aerts et al. (2003) were able to understand the pulsational mode spectrum of the β Cephei V836 Cen and to perform a first seismic analysis of the star. A recent multisite, multitechnique campaign for another β Cephei star, ν Eridani (Handler et al. 2004; Aerts et al. 2004a) enabled seismic modeling as well (Pamyatnykh et al. 2004; Ausseloos et al. 2004).

The success of asteroseismic studies crucially depends on the detection and identification of as many modes of pulsation of the star under consideration as possible. Consequently, excellent measurement accuracy must be reached, which is best done from space.

MOST (*Microvariability and Oscillations of Stars*; Walker et al. 2003) is Canada's first space telescope and the very first dedicated asteroseismology satellite delivering data. It will be followed by *COROT* (Baglin 2003), a French-led European mission with the goal to perform asteroseismic observations as well as to detect exoplanets transiting a parent star.

All these developments in recent years led the authors of this work to the conclusion that it is time for an updated, homogeneous catalog of β Cephei stars. This is not only useful for the target selection process for the upcoming space missions, but also important for the understanding of this group of pulsating stars as a whole.

3. B-TYPE VARIABLES, DEFINITION AND SELECTION OF THE β CEPHEI STARS

As already mentioned, the β Cephei pulsators are generally considered to be early-type B stars (B0–B2.5) with light and radial velocity variations on timescales of several hours. As they are not the only variables of spectral type B, it is important to delineate what separates them from other variables. For instance, the SPB stars are later type B stars (B2–B9) with light, radial velocity, and line profile variability with periods of the order of a few days (De Cat & Aerts 2002).

The Be stars are defined as nonsupergiant B stars having shown Balmer line emission at least once (Collins 1987). They span the whole β Cephei and SPB instability regions and stretch from late O-type to early A-type stars. The hotter Be stars of spectral types B6e and earlier can show light, radial velocity, and line profile variations. Be stars that vary periodically (see Rivinius et al. 2003) are sometimes also called λ Eri stars. Some Be stars can also show additional β Cephei pulsations (see the discussion below).

ζ Ophiuchi stars are OB-type variables that show bumps moving through their line profiles, which may be caused by high-degree nonradial pulsation (Balona & Dziembowski 1999).

Some of the S Doradus stars or LBVs (see, e.g., van Genderen 2001), also have spectral types of or near B.

The chemically peculiar Bp stars can also show light and line profile variations (see, e.g., Briquet et al. 2004), and ellipsoidal variables may be present amongst variable B-type stars as well.

Two rather recently discovered classes of pulsating B stars are the short-period subdwarf B variables (sdBVs), also known as EC 14026 stars (Kilkenny et al. 1997), and the long-period sdBV stars (Green et al. 2003). The periods of the short-period sdBVs range between 2 and 9 minutes, and those of the long-period sdBVs are around 1 hr. Finally, the pulsating DB white dwarf stars also need to be mentioned.

Consequently, it is not easy to classify variable B-type stars correctly, in particular as some overlap between the different groups of variable stars occurs. For instance, β Cephei itself is also a Be and a Bp star (see Hadrava & Harmanec 1996 for a summary).

We therefore suggest the following definition of the β Cephei variables: *The β Cephei stars are massive nonsupergiant variable stars with spectral type O or B whose light, radial velocity and/or line profile variations are caused by low-order pressure and gravity mode pulsations.*

Our choice of this definition was motivated by several reasons. In our view, the main feature on which the classification of a pulsating star is based should be its pulsational behavior. For instance, any class of pulsating stars should be known to be driven by the same self-excitation mechanism, and their pulsational timescales should be different and separable from those of other types of pulsators. Of course, a particular locus in the HR diagram could also assist, and sometimes be incorporated, in the definition of a class of pulsating star.

Since the observational extent of the instability strip of the β Cephei stars may still not be accurately known (cf. § 6), we did not want to limit our definition to a narrow range of spectral types. In addition, we do not take the existence of radial pulsation to be a prerequisite for an object to be classified as a β Cephei star, because this would require a firm observational mode identification, which is in most cases not available. By dropping this criterion that has sometimes been used in the past, we make the pulsation constant our main criterion for classification. We also take into consideration that many β Cephei stars have been shown to pulsate both in radial and nonradial modes, or any subset of these.

To apply our definition to the stars under consideration, we must link it to observables. Consequently, we consider an object to be consistent with our definition of a β Cephei star in practice, if it shows convincing evidence for more than one variability period too short to be consistent with rotational or binarity effects, as checked by estimating the pulsation "constant" Q. Stars with only a single period were accepted if proof of the pulsational nature of the variations was found, such as color or radial velocity to light amplitude ratios typical of pulsation or variability (with, again, the period too short to be accounted for by other effects) present in more than one observable.

4. DESCRIPTION OF THE CATALOG

We list all objects that have to our knowledge ever been claimed to be β Cephei stars or candidates up to 2004 June. We selected them by an extensive search in the literature and in databases (such as SIMBAD), with the aim that we could collect all possible candidates. For all of them, thorough bibliographic studies were performed to investigate the latest findings on their nature. Where the data in the literature were insufficient or inconclusive, we reanalyzed some of the measurements or reevaluated the available information on these stars. We also performed frequency analyses of the *Hipparcos* photometry (ESA 1997) whenever possible to assist with the classification of the variables. We note that because of aliasing problems in the *Hipparcos* data we did not attempt to determine individual periods but mainly used them to check the timescales of the observed variability. Owing to the particular variability timescales involved, aliasing was therefore not a problem for our purposes.

The SIMBAD database initially prompted us with 128 β Cephei stars. Their classification often originated from the General Catalogue of Variable Stars (Kukarkin et al. 1971) and subsequent name lists. We could confirm 66 of these and placed the others either on a list of candidate or rejected β Cephei stars. The other objects in this catalog were selected from our literature searches.

We then scrutinized the literature on all these stars and checked whether they were consistent with our working definition of a β Cephei star. We designate objects that have been claimed as β Cephei stars, but where the observational evidence for their membership to the group is not fully conclusive owing to, e.g., poor or few data, as *candidate β Cephei stars*. Some of these objects will indeed be β Cephei pulsators, whereas others were added to this list because of the lack of evidence that they are not. In any case, all of these objects deserve more observational attention.

Stars that were claimed to be β Cephei variables, but where we found evidence that they are not, are called *rejected β Cephei candidates*. These are objects with variability timescales inconsistent with low-order p- or g-mode pulsation, objects whose claimed variability was disproved by subsequent or more extensive studies, or stars proven to vary because of effects other than β Cephei pulsation, etc. This list also includes stars that were rejected by other authors in order to give a complete overview over all stars that at some point had been considered to be β Cephei stars. We have also scrutinized the list of ζ Oph stars by Balona & Dziembowski (1999) as several of these variables have observed periods in the β Cephei range. We found that the periods *in the corotating frame* are consistent with β Cephei pulsation for only three stars, which we include in this catalog.

The importance of Tables 2 and 3 is, besides their relevance for the description of the β Cephei stars as a group, that they provide completeness of the catalog and that it can be traced how the less convincing candidates were judged by us.

We have not included β Cephei stars or candidates outside our Galaxy into this catalog because detailed lists of the objects reported by Kołaczkowski et al. (2004b) have not yet been published. For reasons of consistency we thus also exclude the LMC β Cephei candidates by Pigulski & Kołaczkowski (2002) and Sterken & Jerzykiewicz (1988).

In Table 1 we present the complete list of Galactic β Cephei stars. Table 2 contains the candidate β Cephei stars, and Table 3 lists the former candidates that are not considered β Cephei stars. In the following, we describe the contents of Table 1. Tables 2 and 3 only contain part of this information.

1. *Identifiers*.—The first five columns of the catalog contain the identifiers of the stars, HD number, HR number or cluster identification, *Hipparcos* numbers, and Durchmusterung (DM) numbers. As DM number for the Southern stars we used the Cordoba Durchmusterung (CD) numbers, not the Cape Photometric (CpD) numbers! Some objects do have CpD numbers, and no CD numbers, such as V1032 Sco.

The sixth column lists different names given to these stars, such as Bayer or Flamsteed numbers, or variable designations according to the General Catalogue of Variable Stars.

2. *Coordinates*.—Right ascension and declination (cols. [7] and [8]) are given with epoch 2000. If inaccurate coordinates were found in the databases, we used a finder chart and matched it to the Digital Sky Survey plates, thereby determining the coordinates to a precision of $\sim 2''$.

3. *Pulsation period*.—The period of pulsation is given in days in column (9). If a star is multiperiodic, the period of the pulsation mode with the highest amplitude is given and an asterisk (*) next to the period indicates the multiperiodicity. We apply the term "monoperiodic" to stars for which only one pulsation frequency was found *up to the current detection limit*. If pulsation was detected photometrically and spectroscopically, we give the photometrically determined period.

4. *Amplitude*.—It is difficult to specify a unique amplitude of a frequency for a variable star measured in different photometric passbands and/or in radial velocity. This applies in particular for the cases of multiperiodicity and amplitude variability. Therefore, we chose the following approach: for all stars with a resolved pulsation spectrum, we list photometric peak-to-peak amplitudes of the strongest pulsation mode. If a star shows amplitude variability caused by beating of unresolved frequencies, we adopt the average peak-to-peak amplitude, and in case of mild amplitude variability of individual modes we adopt the average peak-to-peak amplitude of the strongest mode. For the two stars with the strongest amplitude variations (Spica and 16 Lac) we list no amplitudes. Finally, no amplitude is given for the three stars where only spectroscopic variability was detected. This is denoted as "n/a" in the amplitude column.

We list Johnson V amplitudes whenever possible. If data from this filter were not available, we used Strömgren y, Geneva V (denoted V_G in Table 1), or Walraven V (denoted V_W). In the latter case the logarithmic intensity amplitudes were multiplied by 2.5 to give magnitude units. All these filters have very similar effective wavelengths resulting in directly comparable amplitude values. Some stars have not been observed in these filters. In such cases we chose in order of decreasing preference Strömgren b, Johnson/Cousins R, Johnson B, and Cousins I. The use of data obtained in different filters was only applicable because the pulsation amplitudes of β Cephei stars are very similar in the wavelength range spanned by B to I.

5. *Apparent magnitude and spectral classification*.—The next two columns give the apparent magnitude in Johnson V and the spectral type according to the Morgan and Keenan system (MK). The V magnitudes are taken from The General Catalog of Photometric Data (GCPD)[3] by Mermilliod et al. (1997). The spectral types are taken from the SIMBAD database.

6. *Rotational and radial velocities*.—The projected rotational velocity ($v \sin i$) is given in the next column. If disagreements between different values in the literature were detected, either the more reliable source is quoted here or, if no distinction in quality of the data could be made, the lower value is given. Concerning the radial velocity (RV), the best or mean values are quoted, in an attempt to average out the RV variations over the pulsation cycle. The values for $v \sin i$ and RV are taken from various catalogs of radial velocities, or in some cases from original publications.

7. *Color indices from Strömgren photometry*.—Columns (13)–(16) the Strömgren color indices $(b-y)$, m_1, c_1, and β. These data were obtained from the GCPD. These indices are used in preference to the Geneva colors, which are available for roughly the same number of stars. The Strömgren filters are more widely available and according to our experience, the combination of measurement accuracy and its conversion to theoretical parameters such as effective temperature and surface gravity via calibrations of color photometry favors Strömgren photometry in terms of achieving better accuracy in the derived basic stellar parameters. In addition, only the c_1 index may show some variation over the pulsation cycle of a β Cephei star. We therefore find that the color indices we list are good representations of the mean colors of a star through its pulsation cycle.

For a detailed list of Geneva colors for many β Cephei stars we refer to De Cat (2002; see also footnote 2).

8. *References and notes*.—Numerical references are listed below each table. Short individual notes to several stars can be found in the table, whereas longer discussions of some objects are given in § 8. As references, we list selected papers that are directly related to the stellar pulsations or those which give useful additional information. These would typically be discovery papers, those that reported most about the pulsations, or did further analyses such as mode identifications. We give no more than six references per star.

4.1. *Table of Frequencies*

In Table 4 we present a list of frequencies for the stars from Table 1. We refrain from listing all the claimed frequencies for all stars because the data are qualitatively inhomogeneous and some sources may not be reliable. The choice of frequencies listed originates from critical evaluations of literature data.

[3] See http://obswww.unige.ch/gcpd/gcpd.html.

We consider a photometrically detected frequency as also spectroscopically detected if the variation is present and clearly recognizable in radial velocity analyses or line profile variations, but do not insist on detections in both of these spectroscopic observables.

For several stars, some frequencies reached detectable amplitudes only during some observations. We list all frequencies ever detected from analyses that convinced us.

5. ANALYSIS

5.1. *Basic Observational Quantities*

In this section we present analyses performed on the intrinsic 93 β Cephei variables. We analyze the distribution of spectral type (see Fig. 1), radial velocity (RV), projected rotational velocity ($v \sin i$), apparent brightness in Johnson V and pulsation period (P) (see Fig. 2). In addition, we examine the Galactic distribution (see Fig. 3) as well as the dependence of the pulsational amplitudes on the projected rotational velocities (see Fig. 4), and thereby describe the β Cephei stars as a group.

5.1.1. *Spectral Type and Luminosity Class*

The three-dimensional histogram in Figure 1, which is inspired by Figure 4 of Sterken & Jerzykiewicz (1993), shows the distribution of the confirmed 93 β Cephei stars according to their spectral type and luminosity class. It shows that $\approx$20% of the β Cephei stars appear to be B1 dwarfs. A total of 66% of the stars are of spectral type B1 and B2 and luminosity classes III–V. This distribution resembles very closely the spectral type range occupied by the confirmed β Cephei stars from Sterken & Jerzykiewicz (1993), where almost all stars lie within B0 and B2.5. Most of the class V variables are members of open clusters (80%). Two of the stars from Tab. 1 do not yet have a spectral type assigned (NGC 6910 27 and V2187 Cyg) and for 3 stars no luminosity class was associated to the spectral type (NGC 663 4, NGC 6910 16, and HN Aqr). As will be shown in § 5.2, the assignment of luminosity classes I–III to some of these stars must be erroneous.

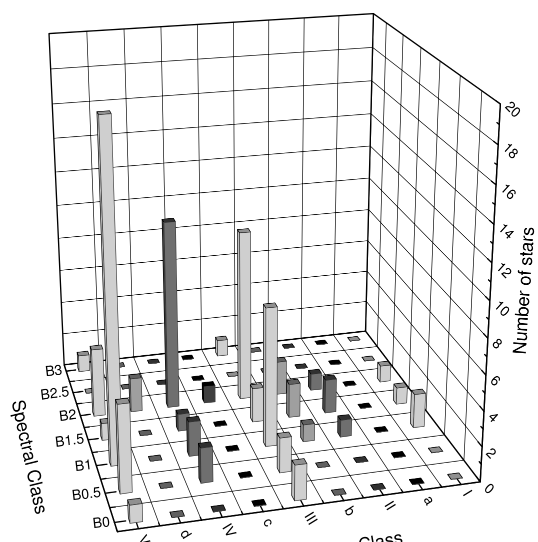

Fig. 1.—Distribution of stars according to spectral type and luminosity class. The letters a, b, c, and d correspond to the intermediate luminosity classes I–II, II–III, III–IV, and IV–V. [*See the electronic edition of the Supplement for a color version of this figure.*]

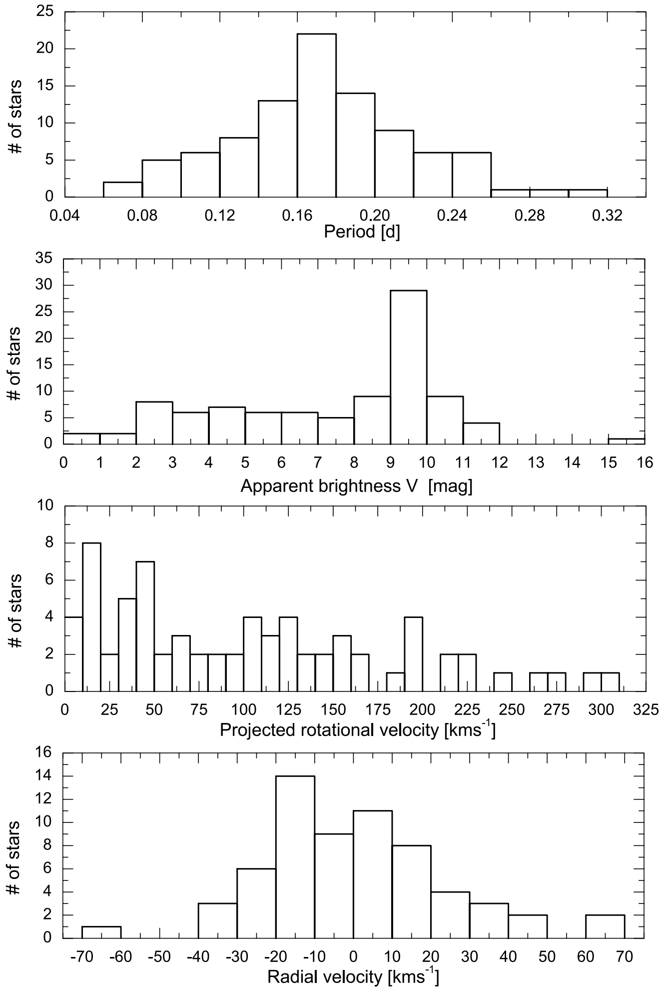

Fig. 2.—Histograms of radial velocity, projected rotational velocity, apparent magnitude, and pulsation period.

5.1.2. *Projected Rotational Velocity*

The range of projected rotational velocity, $v \sin i$, extends from 0 to 300 km s^{-1} with HD 165174 as the fastest rotator with 300 km s^{-1}, closely followed by NGC 4755 I with 296 km s^{-1}. HD 165174 is also a Be star, whereas NGC 4755 I went through

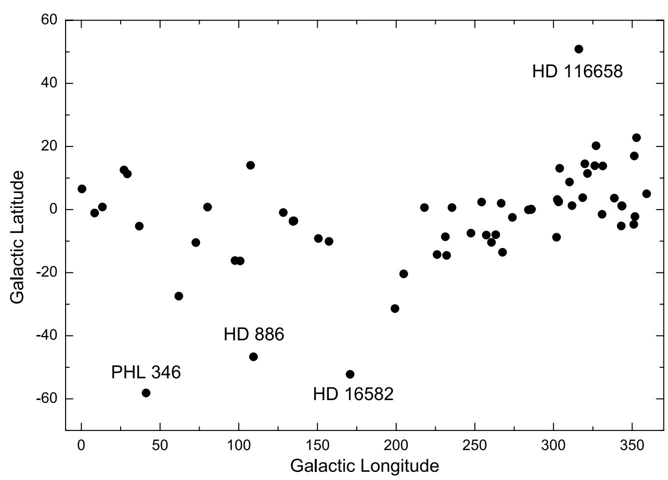

Fig. 3.—Distribution of stars according to Galactic longitude and latitude.

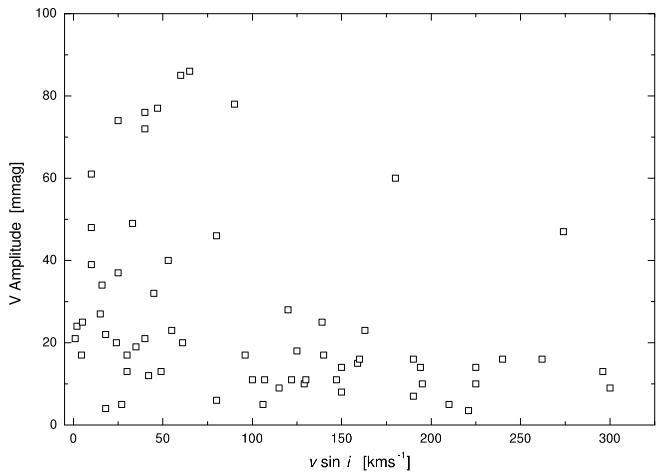

FIG. 4.—Photometric amplitudes of the β Cephei stars depending on their projected rotational velocity.

phases where its pulsations were clearly detectable, but at other times did not reach a detectable level. Most β Cephei stars seem to be rather slow rotators (average $v \sin i \sim 100$ km s^{-1}), although this could in part be due to a selection effect as the highest-amplitude pulsators are slowly rotating stars. Hence, their variability is more easily detectable and observable.

5.1.3. *Radial Velocity*

The radial velocities (RV) of the β Cephei stars, as seen in Figure 2 (*bottom*) appear to be centered around -10 km s^{-1} but stretch up to +65 km s^{-1}. This distribution is that of an average young galactic disk population, which is not surprising.

5.1.4. *Apparent Brightness*

The apparent brightness has a maximum at $V \sim 9.5$ mag with 31% of the stars; these are mostly cluster β Cephei stars. The range of apparent brightness is between 0.6 mag $< V <$ 15.4 mag, with β Cen, α Vir, β Cru, and λ Sco as brightest stars with V between 0.6 mag and 2.0 mag. The faintest stars with V of 11.9 mag and 15.4 mag are HN Aqr and V2187 Cyg, respectively. This information can be relevant for planning observational projects, and can be compared directly to Figure 3 of Rodríguez & Breger (2001).

5.1.5. *Pulsation Period*

The distribution of the pulsation periods has a peak at $\sim$0.17 day, corresponding to 4 hr. The shortest period is 0.0667 day for ω^1 Sco, the next shortest period is from Braes 929 with 0.0671 day. The two longest periods are 0.319 day for Oo 2299 and 0.2907 day for HD 165174.

Hence, we find that the observed range of periods for β Cephei stars is between 0.0667 and 0.319 day or 1.60 and 7.66 hr. The median of all periods is 0.171 day.

Three of the confirmed β Cephei stars show, so far, variability only in their line profiles. They are nevertheless included in the group of β Cephei stars because they exhibit the same basic behavior as the *classical* β Cephei stars. The lack of confirmation of their variability from photometric techniques is due to modes of high-degree ℓ in those stars, which are difficult to detect in photometric observations. We have only retained objects in Table 1 if their corotating variability period was consistent with β Cephei pulsation.

5.1.6. *Galactic Distribution*

The Galactic distribution of the confirmed β Cephei stars is shown in Figure 3. In agreement with the result from § 5.1.3, this again suggests a young disk population. The most interesting objects in this diagram are the "outliers," the only significant one being PHL 346, which may either have formed in the Galactic halo or could be a runaway star (Ramspeck et al. 2001).

5.1.7. *Pulsation Amplitude versus Rotation Rate and Pulsation Period versus Rotation Rate*

The dependence between pulsation amplitude and rotation rate is plotted in Figure 4. With the exception of HD 52918 and HD 203664, only stars with rotation velocities $v \sin i \leq 90$ km s^{-1} show pulsation amplitudes larger than $\sim$25 mmag. This is similar to the behavior of the δ Scuti stars (Breger 1982), and may also lend support to the hypothesis that rotation is an important factor in the amplitude limiting mechanism operating in these types of pulsators. In this context it is interesting to note that the range of the *angular* rotational velocities of high-amplitude δ Scuti stars is very similar to that of the β Cephei stars with the highest amplitudes. For a similar analysis based on the radial velocity pulsation amplitude we refer to Aerts & De Cat (2003).

We also examined the pulsation period versus rotation velocities $v \sin i$ and find that there is no dependence between these two quantities. This is also not a surprise as most of the known β Cephei stars are photometric variables and thus pulsate in modes of low spherical degree.

5.1.8. *Mono-versus Multiperiodicity*

As listed in Table 4, $\sim$40% of the confirmed β Cephei stars are monoperiodic. We suspect that several of these 37 stars may have additional pulsation periods that are undetected so far. On the other hand, our practical criteria to select β Cephei stars are likely to introduce a bias in favor of multiperiodic stars. In any case, it seems safe to say that most β Cephei stars are multiperiodic pulsators.

5.1.9. *Binarity*

Table 1 also contains information on binary β Cephei stars, which are indicated in the Notes column. Summarizing, we can say that there are eight spectroscopic binaries, four additional double-lined spectroscopic binaries, two suspected binaries, one eclipsing binary and one triple system. Thus, we find that $\approx$14% of all β Cephei stars are located in known multiple systems with physically associated companions.

A search for visual binaries in The Catalogue of Components of Double and Multiple Stars (Dommanget & Nys 2002) and the *Hipparcos* and Tycho Catalogs (ESA 1997) reveals that 16 stars of Table 1 are visual binaries. Five of these are already known to be spectroscopic binaries as well. Owing to these small numbers, we refrain from any statistical analysis. We also assume that several additional β Cephei stars will be proven to be spectroscopic binaries in the future.

5.2. *HR-Diagram, Masses, Pulsation Constants, and Period-Luminosity Relation*

To obtain more insight into the behavior of the β Cephei stars as a group, and for purposes of comparison with theoretical results, we have computed their temperatures and luminosities to place them in the HR diagram. To this end, we adopted the programs by Napiwotzki et al. (1993) (which can be used for B stars of all luminosity classes), using published Strömgren

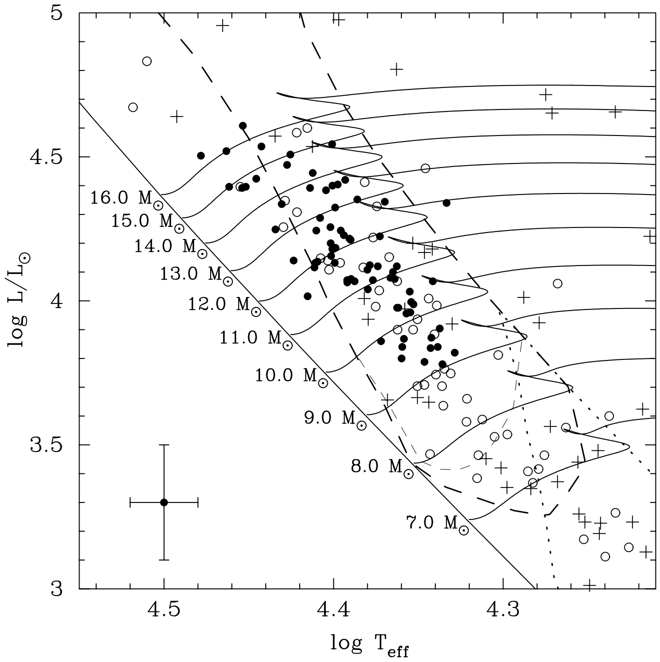

FIG. 5.—Theoretical HR diagram of the confirmed (*filled circles*) and candidate (*open circles*) β Cephei stars as well as the poor and rejected candidates (*plus signs*). The filled circles with the error bars in the lower left corner indicate the rms accuracy of each point in this diagram. The slanted solid line is the ZAMS, the thick dashed line describes the boundaries of the theoretical β Cephei instability strip for $Z = 0.02$, the thin dashed lines are the β Cephei boundaries for radial modes, and the dotted lines those of the SPB stars. Several stellar evolutionary tracks, labeled with their evolutionary masses, are also plotted. All the theoretical results were adopted from Pamyatnykh (1999).

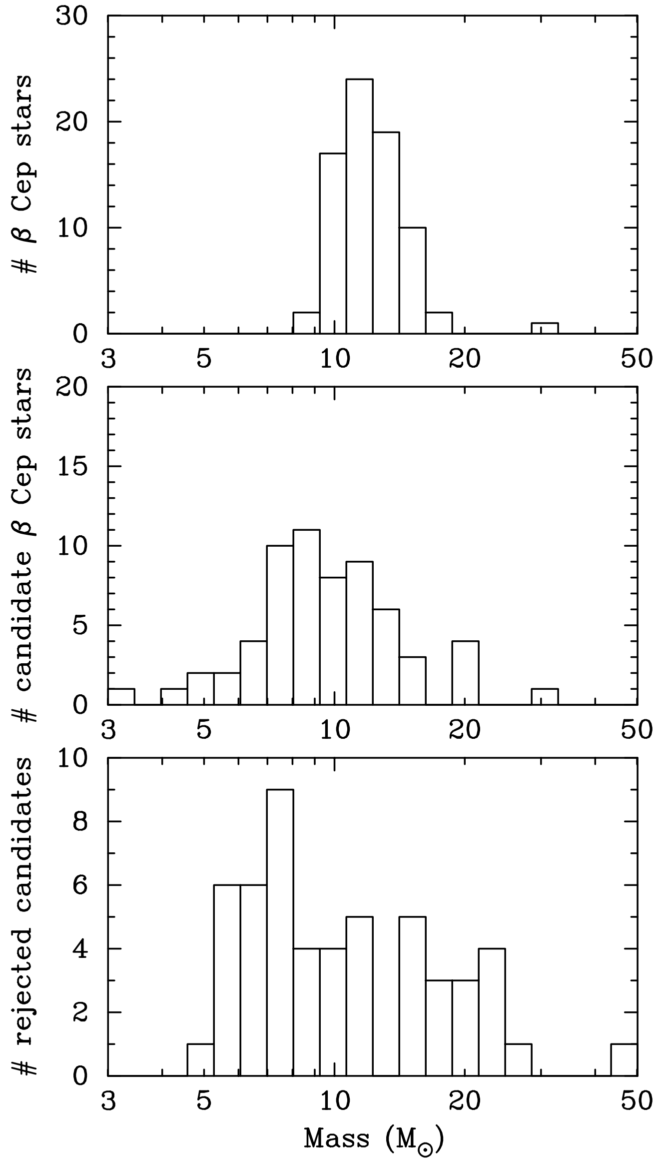

FIG. 6.—Distribution of the masses of the stars in Tables 1–3.

indices from the GCPD to derive $T_{\rm eff}$ via the calibration by Moon & Dworetsky (1985) and M_v from Balona & Shobbrook (1984). We did not use *Hipparcos* parallaxes, as accurate results are only available for a few stars and as we wanted to treat the whole sample homogeneously. We then determined bolometric corrections from the work by Flower (1996). The theoretical HR diagram constructed with these results is shown in Figure 5. The error estimates are ± 0.020 in $T_{\rm eff}$ and ± 0.20 in log L, which are hoped to include external uncertainties in the applied calibrations themselves.

We have also plotted the candidate β Cephei stars (Table 2) and the rejected candidates (Table 3) in this diagram for comparison. We compared the positions of the stars in Figure 5 with evolutionary tracks, which we computed with the Warsaw-New Jersey stellar evolution code (see, e.g., Pamyatnykh et al. 1998). This way we estimated the masses of these objects and we could consequently also compute the pulsation "constant" Q. The pulsation constant was derived from the period with the highest amplitude value. Given the uncertainties in our determinations of $T_{\rm eff}$ and L, we estimate an uncertainty of $\pm 30\%$ in Q. The errors on $T_{\rm eff}$ and L should dominate the error introduced by not being able to use the frequencies in the corotating frame for most stars. This inability is due to missing mode identifications.

We adopted the theoretical boundaries of the β Cephei instability strip from the work by Pamyatnykh (1999). We prefer his results over those by Deng & Xiong (2001) because he applied newer versions of opacity tables and more reliable interpolation routines. The differences between these two approaches are discussed by Pamyatnykh (2002) in detail.

The confirmed β Cephei stars occupy a well-defined region in this plot with the exception of HD 165174, which appears to be so hot and luminous that it falls outside the boundaries of Figure 5. In contrast, the candidates and rejected stars are widely scattered. We note that the theoretically predicted instability strip is not completely filled with stars, a well-known problem that we will discuss in the next section.

In addition, a gap between the coolest β Cephei stars at a given mass and the theoretical TAMS may be suspected. It is unclear whether this is a real feature or whether the derived absolute magnitudes from the Strömgren indices could be biased. Heynderickx et al. (1994) discussed this problem in detail. In any case, it is reasonable to conclude that all known β Cephei stars are main-sequence objects. Consequently, the assignment of luminosity classes I–III to several confirmed β Cephei stars must be erroneous.

We can now also examine the mass distribution of the β Cephei stars and candidates (Fig. 6). The mass of the confirmed β Cephei stars peaks sharply at about 12 $M_\odot$. Whereas there is a slight indication for a similar maximum for the candidate β Cephei stars, the histogram of the masses of the rejected stars is featureless.

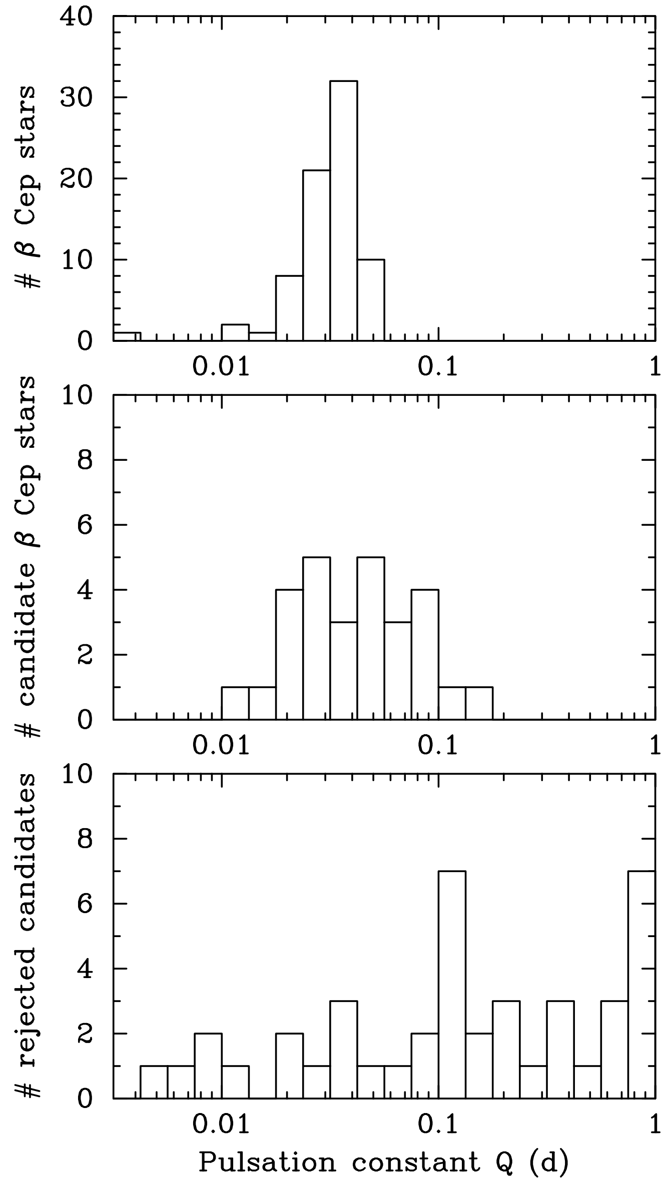

FIG. 7.—Distribution of the pulsation constant Q of the stars in Tables 1–3.

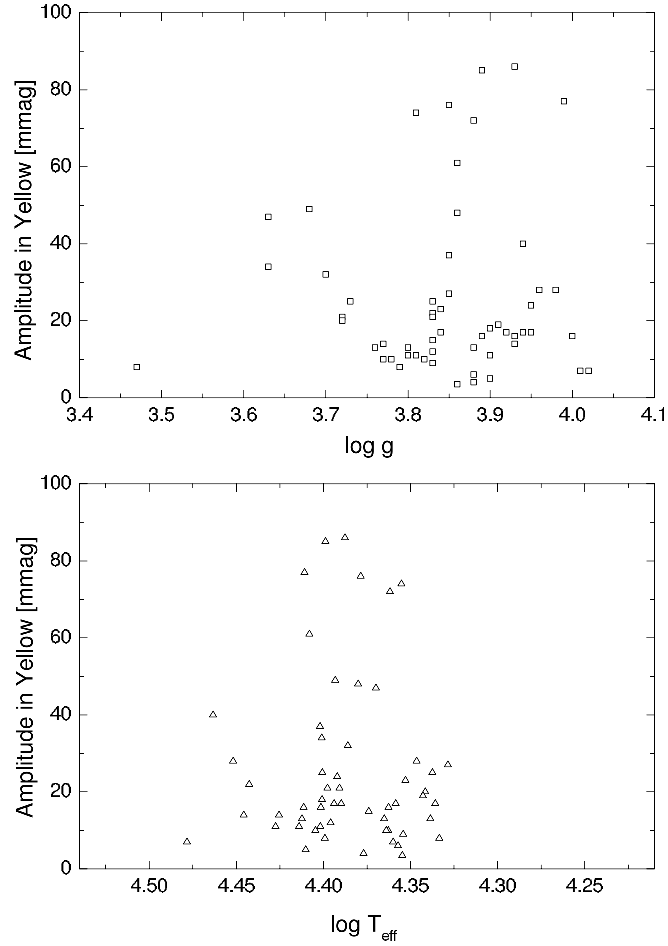

FIG. 8.—*Upper panel*: log g vs. amplitude. *Lower panel*: log $T_{\rm eff}$ vs. amplitude. The x-axis here shows the same scale as the x-axis in Fig. 5. The amplitudes in Johnson V and Strömgren y are shown for all stars where Strömgren indices were available. The amplitudes of the strongest modes are shown here as listed in Table 4.

Turning to the pulsation constant (Fig. 7), we again see a sharp peak for the confirmed β Cephei stars located at $Q = 0.033$ day, corresponding to the value for radial fundamental mode pulsation. More than half of the candidate β Cephei stars have Q-values in the same range, although there is a tail toward higher Q. We remind that several stars were classified as candidate β Cephei stars because of the lack of evidence that they are *not* pulsators. The histogram of Q of the rejected candidates shows no particular preferences. It is clear that Q-values for nonpulsating stars have no real relevance, but our aim here is to check whether our separation of the candidates in the three groups was successful. Comparing the different panels within Figure 6 and Figure 7, respectively, implies that the choice of our selection criteria is justified.

6. THE OBSERVATIONAL BOUNDARIES OF β CEPHEI PULSATION

As mentioned in §§ 2 and 5.2, several authors computed the instability region for β Cephei stars. Linear nonadiabatic analyses for low-degree ($\ell \leq 2$) modes predict that photometrically observable modes are also driven in slightly evolved O-type stars (e.g., Dziembowski & Pamyatnykh 1993), suggesting that there could be a population of late O-type β Cephei stars.

In 1998, the central region of the Cygnus OB2 association was investigated in search of short-period hot pulsators (Pigulski & Kołaczkowski 1998). No β Cephei type stars were found among the O-type variables. So far, only one O-type star, HD 34656 (O7e III) has been suggested to exhibit pulsations in the β Cephei domain (Fullerton et al. 1991). Pulsation was claimed from radial velocity measurements; the given period of 8.81 hr is a little above the typical range of pulsation periods for these stars. The authors were reluctant to identify this star as a β Cephei star. In addition, we are unsure whether the reported radial velocity variations of the star are statistically significant. Therefore, we cannot accept this O-star as a confirmed β Cephei star and place it therefore in Table 2.

There have been several similar attempts to discover O-type β Cephei pulsators observationally (e.g., Balona 1992). However, to date no convincing detections were made, and, with the exception of the Be star HD 165174, there is consequently an apparently well-defined high-mass edge to the population in the resulting HR-diagram (Fig. 5).

From Figure 5 we see that the blue edge is a cutoff for stars more luminous than $\log L_{\odot} = 4.6$ and hotter than $\log T_{\rm eff} = 4.48$. This result can be compared directly with Figure 8, where we show the pulsation amplitudes versus log g and log $T_{\rm eff}$ (*upper and lower panel*, respectively). In the lower panel we see that the highest pulsation amplitudes occur in the middle of the instability region, as is expected because of the strong dependence of the κ-mechanism on temperature and hence on the depth of the ionization layer in which it operates. This diagram also suggests that O-type β Cephei stars could exist, but that their pulsation amplitudes are small and therefore not yet detectable. Space missions could enable us to detect such pulsators.

There could be many reasons for the lack of observed O-type β Cephei stars, as mentioned above. The theoretical models may not necessarily predict the real behavior of the stars, as some physics may be missing from the models. For example, the linear approach taken in the calculation of pulsation instability may not realistically reflect the complex physical processes in real stars, such as the onset of strong stellar winds. As mentioned before, it is also possible that O-type β Cephei stars do exist, but with amplitudes below the current detection limits. In combination, these factors could prohibit the detection of O-type β Cephei stars (see also Pigulski & Kołaczkowski 1998).

In a recent publication, Tian et al. (2003) analyze a sample of 49 presumable β Cephei stars and show a HRD together with theoretical boundaries for the instability region computed by Deng & Xiong (2001). Their computations also include a boundary at the high-mass end of the instability region, which stands in contrast to the theoretical work of Pamyatnykh (1999) (see above). We compared their list of stars with our results and find that 27 of those stars are in our list of confirmed β Cephei stars, 6 are classified as candidates and the remaining 16 are in the list of rejected stars. When we compare their HRD with Figure 5, we see that the boundaries adopted by Tian et al. (2003) encompass all stars from Table 1. Therefore, from an empirical point of view, both instability regions by Pamyatnykh (1999) and Deng & Xiong (2001) fit our sample equally well.

The theoretical β Cephei instability strip is also not filled at the low-mass (red) end. As the theoretical results seem to be more reliable in this part of the HR diagram, the only explanation we have for this finding is again that the pulsational amplitudes are too small to be detected by current methods. We base this argument on analogy with the δ Scuti stars, whose pulsations are of the same nature (low-order p- and g-modes driven by the κ-mechanism) as those of the β Cephei stars, and whose number increases strongly with better detection levels (see, e.g., Breger 1979, Fig. 3). Support for this suggestion comes from intensive observations of individual β Cephei stars (see, e.g., Handler et al. 2003; Jerzykiewicz et al. 2005), for which more and more pulsation modes were detected with decreasing detection threshold.

We note that the low-mass boundary of the theoretical instability strip in Figure 5 for radial modes agrees better with the observations, but it is still too cool to be explained by errors in the temperature calibrations of the observed stars.

The empirical determination of the edges of the instability region is a very interesting challenge in the field of β Cephei stars. New surveys of the late O-type stars and early to mid B-type stars would therefore be of considerable astrophysical interest.

7. CONCLUSIONS

Of the 231 stars under consideration, 93 were confirmed as β Cephei type variable stars (Table 1). Their spectral types range from B0 to B3 with one exception, NGC 663 4, whose spectral type of B5 does not appear to be reliable. The periods of the strongest pulsation modes range from $P = 0.0667$ to 0.319 day or 1.6 to 7.7 hr with a median of 0.171 day. Projected rotational velocities $v \sin i$ range from 0 to 300 km s^{-1}, with a typical value of around 100 km s^{-1}. This suggests that β Cephei stars are rather slow rotators, although this result could be affected by a bias in detecting possible low-amplitude modes occurring in rapidly rotating stars. We expect more detections of β Cephei stars concerning lower amplitude, higher $v \sin i$ stars with space observations in the near future. The Galactic distribution of these stars does not yield evidence for a pulsator that has formed at high Galactic latitude.

There are 77 stars for which no clear classification could be made as a result of limited or conflicting data. These are listed in Table 2 as suspected β Cephei type variable stars; they deserve further attention. Additional notes are provided on interesting characteristics of 19 of these stars. Many of these stars seem good β Cephei candidates and it was often only the lack of recent data that forced us to put them in the list of candidate β Cephei stars.

Despite their previous classification as β Cephei type variables or candidates, 61 of the stars could not be considered as such (Table 3). In some cases authors were overconfident in classifying them as β Cephei stars. In other cases, later measurements have shown that they are either a different kind of variable, or that their variability is no longer detectable, casting doubt on the original observations. Some misclassifications are also due to historical reasons since, during the early days of work on β Cephei stars, the group was not as well known as it is today.

The pulsation constant Q calculated for all confirmed β Cephei stars lies below $Q = 0.06$ day with a peak at $Q = 0.033$ day. The Q-value encompasses many physical parameters, and its use as an observational constraint to classify this group of variable stars is therefore considered more accurate than previous classification techniques. These techniques often relied more heavily on limited information such as spectral type classification and pulsation period. This upper limit of $Q = 0.06$ day can provide an additional observational constraint for the classification of β Cephei stars, keeping the uncertainties in the determination of Q in mind.

The theoretical instability region for the β Cephei stars, as calculated by Pamyatnykh (1999), is not populated at both the low-mass/red end and the blue end. The lack of stars at the blue end, where one would expect late O-type stars, is expected (e.g., Balona 1992; Pigulski & Kołaczkowski 1998). We emphasize that this gap could be due to limitations in the theoretical modeling of the instability region, as well as to the difficulties inherent to observing hot stars exhibiting strong stellar winds and to possible pulsation amplitudes too low to be detected with past and present methods.

It is hoped that our new and refined catalog provides a useful framework within which to plan future observing campaigns, both ground-based and using the upcoming spaceborne observatories. The table of suspected β Cephei variables provides a list of 77 interesting candidates that require further investigation. In addition, the catalog provides improved constraints on the classification and physical nature of β Cephei variables, and these can in turn be used to correctly classify new early-type short-period variable stars.

8. TABLES

In Table 1 we present all confirmed β Cephei stars. In Table 2 we list candidate β Cephei stars and in Table 3 we give rejected β Cephei candidates. At the end of each table we give notes on individual stars as well as short explanations on interesting characteristics of some stars. Table 4 contains a list of pulsation frequencies for all stars from Table 1.

TABLE 1

Catalog of Galactic β Cephei Stars

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Period (days) (9)	V (mag) (10)	Spectral Type (11)
886	1067	γ Peg	39	+14 14	Algenib	00 13 14	+15 11 00	0.1518	2.8	B2 IV
				+60 282	V909 Cas	01 36 39	+61 25 54	0.207	10.5	B1 III
			NGC 663 4			01 46 39	+61 14 06	0.194	11.0	B5
		Oo 692	NGC 869 692	+56 501	V611 Per	02 18 30	+57 09 03	0.1717	9.3	B0 V
			NGC 869 839	+56 508	V665 Per	02 18 48	+57 17 08	0.1949*	9.5	B2 V
		Oo 992	NGC 869 992	+56 520	V614 Per	02 19 00	+57 08 44	0.1326	9.9	B1 Vn
		Oo 2246	NGC 884 2246	+56 572		02 22 03	+57 08 26	0.1842*	9.9	B2 III
		Oo 2299	NGC 884 2299	+56 575	V595 Per	02 22 09	+57 08 28	0.319	9.1	B0.5 IV
16582	12387	δ Cet	779	−00 406	82 Cet	02 39 28	+00 19 42	0.1611	4.1	B2 IV
21803	16516	KP Per	1072	+44 734		03 32 38	+44 51 20	0.2018*	6.4	B2 IV
24760	18532	ϵ Per	1220	+39 895	45 Per	03 57 51	+40 00 36	0.1603*	2.9	B0.5 V
29248	21444	ν Eri	1463	−03 834	48 Eri	04 36 19	−03 21 08	0.1735*	3.9	B2 III
35411	25281	η Ori	1788	−02 1235	28 Ori	05 24 29	−02 23 50	0.13	3.2	B0.5 V
35715	25473	ψ^2 Ori	1811	+02 962	30 Ori	05 26 50	+03 05 44	0.0954*	4.6	B2 IV
44743	30324	β CMa	2294	−17 1467	Mirzam	06 22 41	−17 57 21	0.2513*	2.0	B1 II–III
46328	31125	ξ^1 CMa	2387	−23 3991	4 CMa	06 31 51	−23 25 06	0.2096	4.3	B1 III
50707	33092	EY CMa	2571	−20 1616	15 CMa	06 53 32	−20 13 27	0.1846*	4.8	B1 Ib
52918	33971	19 Mon	2648	−04 1788	V637 Mon	07 02 55	−04 14 21	0.1912*	4.9	B1 V
56014	34981	EW CMa	2745	−26 4057	27 CMa	07 14 15	−26 21 09	0.0919	4.7	B3 IIIe
59864	36500			−33 3879	V350 Pup	07 30 34	−34 05 26	0.238*	7.6	B1 III
61068	37036	PT Pup	2928	−19 1967		07 36 41	−19 42 08	0.1664*	5.7	B2 II
64365	38370	QU Pup	3078	−42 3610		07 51 40	−42 53 17	0.1678*	6.0	B2 IV
64722	38438		3088	−54 1966	V372 Car	07 52 29	−54 22 01	0.1034*	5.7	B1.5 IV
71913	41586	YZ Pyx		−34 4858		08 28 42	−34 43 53	0.2058	7.7	B1.5 II
78616	44790	KK Vel		−44 5150		09 07 42	−44 37 56	0.2157	6.8	B2 II–III
80383		IL Vel		−52 2955		09 17 31	−52 50 19	0.1832*	9.2	B2 III
90288				−56 3324	V433 Car	10 23 57	−57 27 52	0.1095*	8.2	B2 III–IV
303068			NGC 3293 11	−57 3329		10 34 48	−58 08 54	0.1458*	9.8	B1 V
303067			NGC 3293 10	−57 3340	V401 Car	10 35 30	−58 12 00	0.1684*	9.5	B1 V
			NGC 3293 16	−57 3344	V403 Car	10 35 41	−58 12 45	0.2506	8.7	B1 IV
			NGC 3293 65		V412 Car	10 35 45	−58 14 00	0.1135	9.9	B1 V
			NGC 3293 23		V404 Car	10 35 47	−58 14 30	0.1621	9.2	B1 III
			NGC 3293 14		V405 Car	10 35 48	−58 12 33	0.1524*	9.3	B0.5 V
			NGC 3293 24		V378 Car	10 35 54	−58 14 48	0.16*	9.2	B1 III
			NGC 3293 133		V440 Car	10 35 55	−58 13 00	0.179	9.1	B1 III
			NGC 3293 18		V406 Car	10 35 58	−58 12 30	0.1756*	9.3	B1 V
			NGC 3293 27	−57 3351	V380 Car	10 36 02	−58 15 10	0.227	8.9	B0.5 III
92024			NGC 3293 5	−57 3354	V381 Car	10 36 08	−58 13 05	0.1773*	9.0	B1 III
109885	61751	KZ Mus		−70 955		12 39 19	−71 37 18	0.1706*	9.0	B2 III
111123	62434	β Cru	4853		Mimosa	12 47 43	−59 41 19	0.1912*	1.3	B0.5 IV
		BS Cru	NGC 4755G (7)	−59 4454		12 53 21	−60 23 21	0.1508*	9.8	B0.5 V
			NGC 4755 113			12 53 26	−60 22 26	0.2332	10.2	B1 V
			NGC 4755 405			12 53 38	−60 22 39	0.1252*	10.2	B2 V
		CT Cru	NGC 4755 301			12 53 44	−60 22 29	0.1305	9.8	B1 V
		CV Cru	NGC 4755 I (9)			12 53 47	−60 18 47	0.1789*	9.9	B1 Vn
		CZ Cru	NGC 4755 202			12 53 52	−60 21 52	0.1589*	10.1	B1 V
		CX Cru	NGC 4755 201			12 53 52	−60 22 15	0.1825	9.4	B1 V
	62937	CY Cru	NGC 4755 307			12 53 52	−60 22 28	0.1592	9.7	B1 V
			NGC 4755 210			12 53 53	−60 21 46	0.0933	10.3	B2 Vn
	62949	BW Cru	NGC 4755 F (6)		ALS 2816	12 53 58	−60 24 58	0.2049*	9.1	B2 III
112481	63250			−49 7513	V856 Cen	12 57 36	−49 46 50	0.2596*	8.4	B2 Ib
116658	65474	α Vir	5056	−10 3672	Spica	13 25 11	−11 09 40	0.2717	0.9	B1 IV
118716	66657	ϵ Cen	5132	−52 5743		13 39 53	−53 27 59	0.1696*	2.3	B1 V
122451	68702	β Cen	5267	−59 5054	Agena	14 03 49	−60 22 22	0.1535*	0.6	B1 II
126341	70574	τ^1 Lup	5395	−44 9322	1 Lup	14 26 08	−45 13 17	0.1774	4.6	B2 IV
129056	71860	α Lup	5469	−46 9501		14 41 55	−47 23 17	0.2598*	2.3	B1.5 III
129557	72121	BU Cir	5488	−55 5809		14 45 10	−55 36 05	0.1276*	6.1	B2 IV
129929	72241			−36 9605	V836 Cen	14 46 25	−37 13 19	0.1431*	8.1	B3 V
136298	75141	δ Lup	5695	−40 9538		15 21 22	−40 38 51	0.1655	3.2	B2 IV
144470	78933	ω^1 Sco	5993	−20 4405	9 Sco	16 06 48	−20 40 09	0.0667	3.9	B1 V
145794				−52 7312	V349 Nor	16 15 26	−52 55 15	0.1599*	8.7	B2 II–III

TABLE 1—*Continued*

HD	$v \sin i$ (km s^{-1}) (12)	$(b-y)$ (mag) (13)	m_1 (14)	c_1 (15)	β (mag) (16)	RV (km s^{-1}) (17)	Ampl. (mmag) (18)	References (19)	Notes (20)
886..............	4.5	−0.107	0.093	0.116	2.627	3.5	17 (V)	1, 2, 3, 4	Visual binary
							50 (R)	5	
		0.486	−0.160	0.122	2.619		40 (V)	6, 7	Spectral type doubtful
							19 (V)	8	
							43 (V)	9	
							3 (V)	8	
							11 (V)	10	
	160						16 (V)	10, 11	
16582...........	5	−0.099	0.091	0.102	2.616	12.7	25 (V)	1, 2, 3, 12, 13	
21803...........	40	0.082	0.023	0.102	2.617	2.4	72 (V)	1, 2, 14, 15	
24760...........	130	−0.074	0.055	−0.047	2.594	0.8	11 (Hp)	3, 16, 17	Visual binary; amplitude from this paper
29248...........	25	−0.076	0.068	0.072	2.610	14.9	74 (y)	1, 2, 18, 19, 20, 21	Visual binary
35411...........	130	−0.058	0.071	−0.010	2.608	19.8	n/a	3, 22, 23	Eclipsing binary; multiple system
35715...........	141	−0.088	0.075	0.033	2.619	12	n/a	3, 18, 21, 24	Double-lined spectroscopic binary; visual binary
44743...........	1	−0.091	0.054	−0.003	2.593	33.7	21 (V)	2, 3, 18, 25, 26, 27	Visual binary
46328...........	16	−0.093	0.064	−0.022	2.585	26.9	34 (V)	1, 2, 14, 28	Visual binary
50707...........	49	−0.087	0.071	−0.014	2.594	28	13 (V)	1, 12, 14, 21, 26, 29	
52918...........	274	−0.073	0.065	0.023	2.591	32	47 (y)	1, 3, 30, 31, 32	
56014...........	150	−0.067	0.070	0.168	2.572	+16	8 (V)	32, 33, 34	Visual binary
59864...........		0.003	0.061	0.022	2.599	44	16 (B)	14, 28, 35, 36	
61068...........	10	−0.068	0.077	0.050	2.617	22	39 (b)	1, 8, 17, 37, 38	
64365...........	∼30	−0.075	0.076	0.112	2.622	32.2	13 (V_W)	1, 18, 21, 28	
64722...........	147	−0.046	0.075	0.023	2.610	18	11 (V_W)	1, 21, 28	
71913...........		−0.012	0.052	0.024	2.594		32 (V_G)	39	
78616...........	10	0.060	0.039	0.068	2.611	26	48 (V)	1, 3, 14, 35, 40	Visual binary
80383...........	65	0.097	0.013	0.072	2.617	19	86 (V)	1, 41	Visual binary
90288...........	240	−0.040	0.054	0.020	2.622	4	16 (V)	1, 28, 38, 41	Visual binary
303068.........	42	0.060	0.037	0.045	2.611	−7	12 (y)	1, 42, 43	
303067.........	125	0.082	0.034	0.047	2.604	−10	18 (y)	1, 14, 42, 44, 45	
	33	0.048	0.040	0.023	2.591	−23	49 (y)	1, 14, 42, 44, 45	
		0.074	0.037	0.073	2.585		8 (y)	42, 45, 46	
	10	0.083	0.025	0.036	2.604	3	61 (y)	28, 42, 45	
	129	0.020	0.048	0.016	2.596	−14	10 (y)	1, 42, 44, 45	
	194	0.089	0.025	0.006	2.593	−12	14 (y)	1, 14, 35, 42, 44, 45	
	225						14 (y)	42, 45	
	40	0.038	0.050	0.045	2.605	−16	21 (y)	1, 14, 35, 42, 44, 45	Visual binary
	61	0.122	−0.001	0.073	2.60	−15	20 (y)	1, 14, 35, 42, 45, 46	
92024...........	122	0.035	0.035	0.014	2.598	−16	11 (y)	1, 35, 42, 44, 45, 47	Eclipsing binary
109885.........	47	0.173	−0.010	0.060	2.620	−61.1	77 (V)	39, 41, 48, 49	
111123.........	18	−0.103	0.061	−0.041	2.596	15.6	22 (V)	2, 3, 12, 35, 50, 51	Visual binary
	27	0.175	−0.018	0.056	2.609	−23	5 (V)	42, 52, 53	
	106	0.172	0.019	0.116	2.632	−19	5 (B)	42, 52, 53, 54	
	18	0.146	0.023	0.090	2.613	−18	4 (V)	52, 53, 55	
	225	0.179	−0.021	0.103	2.605	−6	10 (V)	42, 52, 53, 54	
	296	0.227	−0.023	0.112	2.607	−32	13 (V)	42, 52, 53	
	262	0.148	0.020	0.113	2.617	−33	16 (V)	42, 52, 54	
	195	0.153	0.005	0.102	2.609	−16	10 (V)	42, 52, 53	
	107	0.174	−0.028	0.152	2.620	−27	11 (B)	42, 52, 53, 54	
		0.177	0.022	0.136	2.634		7 (V)	42, 52, 56	
	96	0.143	0.002	0.062	2.605	−22	17 (V)	42, 52, 53	
112481.........					2.604	−19	34 (V_G)	1, 35, 57, 58	
116658.........	160	−0.114	0.080	0.018	2.605	1	Var.	2, 3, 18, 28, 35, 50	Ellipsoidal variable
118716.........	159	−0.094	0.058	0.043	2.608	3	15 (V_W)	1, 3, 21, 35, 50, 59	Visual binary
122451.........	139	−0.092	0.045	−0.004	2.594	5.9	25 (V)	3, 21, 35, 43, 60, 61	Suspected binary (80)
126341.........	15	−0.047	0.064	0.132	2.621	−21.5	27 (V)	1, 2, 35, 50, 62	Visual binary
129056.........	24	−0.086	0.071	0.080	2.604	5.2	20 (V_W)	1, 2, 3, 21, 35, 62	Visual binary
129557.........	30	0.036	0.027	0.058	2.617	−6.4	17 (y)	1, 35, 62, 63	Visual binary
129929.........	2	−0.059	0.058	0.038	2.618	66	24 (V_G)	1, 28, 57, 64, 65	
136298.........	221	−0.101	0.075	0.076	2.616	0.2	3.5 (V)	12, 21, 35, 66, 67	
144470.........	89	0.037	0.043	0.010	2.618	−2.6	n/a	3, 21, 68, 69	Only spectroscopic variability detected so far
145794.........					2.615		28 (V_G)	1, 28, 38, 58	Spectroscopic binary

TABLE 1—*Continued*

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Period (days) (9)	V (mag) (10)	Spectral Type (11)
147165..........	80112	σ Sco	6084	−25 11485	20 Sco	16 21 11	−25 35 34	0.2468*	2.9	B1 III
147985..........	80653			−43 10792	V348 Nor	16 26 57	−43 47 57	0.1323*	7.9	B1.5 II–III
		Braes 929	NGC 6231 253	−41 11018p	V945 Sco	16 53 55	−41 52 15	0.0671	9.6	B1 V
		Braes 930	NGC 6231 282		V1032 Sco	16 53 59	−41 48 42	0.1193*	9.8	B2 V
		Braes 932	NGC 6231 261	−41 11028	V946 Sco	16 54 02	−41 51 12	0.0988*	10.3	B2 IV–Vn
326330..........		Braes 672	NGC 6231 238		V964 Sco	16 54 18	−41 51 36	0.0878*	9.6	B1 Vn
		Braes 948	NGC 6231 110	−41 11056	V947 Sco	16 54 35	−41 53 39	0.1079*	9.8	B1 V
326333..........		Braes 675	NGC 6231 150	−41 11059	V920 Sco	16 54 43	−41 49 36	0.1012*	9.6	B1 Vn
156327B.......	84655			−34 11622	V1035 Sco	17 18 23	−34 24 31	0.146*	9.4	WC7 + B0 III
156662..........				−45 11411	V831 Ara	17 21 06	−45 58 56	0.1689*	7.8	B2 III
157056..........	84970	θ Oph	6453	−24 13292	42 Oph	17 22 01	−24 59 58	0.1405*	3.3	B2 IV
157485..........	85189			−26 12112	V2371 Oph	17 24 35	−26 55 29	0.2212*	9.1	B1.5 Ib
158926..........	85927	λ Sco	6527	−37 11673	Shaula	17 33 37	−37 06 14	0.2137*	1.6	B2 IV
160578..........	86670	κ Sco	6580	−38 12137		17 42 29	−39 01 48	0.1998	2.4	B1.5 III
163472..........	87812		6684	+00 3813	V2052 Oph	17 56 18	+00 40 13	0.1399*	5.8	B2 IV–V
164340..........	88352			−40 12092		18 02 33	−40 05 16	0.1529	9.3	B2 IV–V
165174..........	88522		6747	+01 3578	V986 Oph	18 04 37	+01 55 08	0.2907	6.2	B0 IIIn
165812..........	88884			−22 4581	V4382 Sgr	18 08 45	−22 09 38	0.1759*	7.9	B1.5 II
166540..........	89164			−16 4747	V4159 Sgr	18 11 48	−16 53 38	0.233*	8.1	B1 Ib
180642..........	94793			+00 4159	V1449 Aql	19 17 15	+01 03 34	0.1822	8.3	B1.5 II–III
			NGC 6910 18			20 22 59	+40 45 39	0.1565*	10.8	B1 V
			NGC 6910 16			20 23 07	+40 46 56	0.1922*	10.7	B3
			NGC 6910 14			20 23 08	+40 46 09	0.1904	10.4	B0.5 V
			NGC 6910 27			20 23 34	+40 45 20	0.143	11.8	
		V2187 Cyg				20 33 18	+41 17 39	0.2539	15.4	
199140..........	103191	BW Vul	8007	+27 3909		20 54 22	+28 31 19	0.201	6.5	B2 III
203664..........	105614	SY Equ		+09 4793		21 23 29	+09 55 55	0.1659*	8.6	B0.5 IIIn
205021..........	106032	β Cep	8238	+69 1173	Alfirk	21 28 40	+70 33 39	0.1905*	3.2	B2 IIIe
			NGC 7235 8			22 12 34	+57 15 29	0.2029*	11.9	B1.5 V
		HN Aqr			PHL 346	22 37 38	−18 39 51	0.1523	11.5	B2
214993..........	112031	DD Lac	8640	+39 4912	12 Lac	22 41 29	+40 13 21	0.1931*	5.3	B2 III
216916..........	113281	EN Lac	8725	+40 4949	16 Lac	22 56 24	+41 36 14	0.1692*	5.6	B2 IV

8.1. *Omitted Stars*

Several candidate β Cephei stars in Table 2 originate from the line profile variability surveys of Telting et al. (2002) and Schrijvers et al. (2002). They were not directly claimed as β Cephei candidates by these authors. Stars that show line profile variability but where we discovered that the variations are likely not to originate in nonradial pulsation do not appear in the following tables at all.

HD 11241 (1 Per).—No periodicities in the spectroscopic data of Janík et al. (2003).

HD 48977 (16 Mon).—Probably a rotationally variable star.

HD 64503 (QZ Pup).—Ellipsoidal variable with a residual variability of $P \sim 1$ day, see Haefner & Drechsel (1986).

HD 64740.—Rotational variable with a period of 1.33 days, see Lester (1979).

HD 154445.—*Hipparcos* data analysis results in a period of 4.5916 days with a peak-to-peak amplitude of 19 mmag.

HD 169467 (α Tel).—Microvariable in *Hipparcos* with a period of 0.909 day; it also is a He rich star and we suspect it to be a SPB star.

HD 172910.—*Hipparcos* data results in two periods: 1.1983 and 0.9812 days, and we suspect it to be a SPB star.

A similar comment applies to the ζ Ophiuchi stars listed in Table 1 of Balona & Dziembowski (1999). Objects from that work which can have corotating variability periods too long to be due to β Cephei-type pulsation as described by us were not included in this catalog.

8.2. *Notes on Individual β Cephei Stars*

V595 Per.—The period of its light variation is somewhat long and there seems to be only one. The position of this star in the HR diagram of Krzesiński & Pigulski (1997) leads to a pulsation constant of 0.039 day. In β Cephei models the value of Q for the radial fundamental mode is between 0.034 and 0.041 day (if one only looks at modes excited in solar-metallicity models, the upper

TABLE 1—*Continued*

HD	$v \sin i$ (km s^{-1}) (12)	$(b-y)$ (mag) (13)	m_1 (14)	c_1 (15)	β (mag) (16)	RV (km s^{-1}) (17)	Ampl. (mmag) (18)	References (19)	Notes (20)
147165...........	53	0.168	−0.032	0.003	2.604	−1	40 (V)	1, 3, 21, 70, 71, 72	Spectroscopic binary
147985...........	80						46 (V)	1, 3, 38, 73, 74	
	100	0.206	−0.020	0.031	2.596	Var.	11 (y)	75, 76, 77, 78	Double-lined spectroscopic binary
	80	0.201	−0.015	0.131	2.617		6 (y)	75, 76, 79	Double-lined spectroscopic binary
	140	0.228	−0.046	0.144	2.626	−32	17 (y)	75, 76, 77, 78, 80	Suspected binary (80)
326330...........	210	0.198	−0.004	0.015	2.615	−30, var	5 (y)	75, 76, 79	
	190	0.237	−0.011	0.006	2.612		7 (y)	75, 76, 77, 78	Double-lined spectroscopic binary
326333...........	150	0.215	−0.013	0.026	2.606	−47, var	14 (y)	51, 75, 76, 80	Suspected binary (80)
156327B.........							35 (V)	81	Eclipsing binary
156662...........	190	0.200	−0.044	0.074	2.614		16 (V_G)	1, 38, 73	
157056...........	35	−0.092	0.089	0.104	2.624	−5.6, var?	19 (y)	1, 21, 38, 82, 83, 84	Visual binary
157485...........					2.623		48 (V_G)	39	
158926...........	163	−0.105	0.072	0.074	2.613	18.6, var	23 (V)	1, 3, 21, 22, 85, 86	Spectroscopic triple system
160578...........	115	−0.100	0.073	0.073	2.613	0.2,var	9 (V)	2, 3, 85, 86, 87	Spectroscopic binary
163472...........	120	0.128	0.017	0.145	2.630	−17.6	28 (V)	1, 21, 38, 88, 89, 90, 91	Magnetic star
164340...........					2.584		25 (V)	92, 93	
165174...........	300	0.075	0.000	−0.119	2.567	+17, var	9 (b)	15, 94, 95, 96, 97, 98	Spectroscopic binary; mild Be star
165812...........		0.079	0.029	−0.001	2.611	−24	28 (V_G)	39, 99	Periods from *Hipparcos* photometry and Geneva data disagree
166540...........	55					−1.6	23 (V)	100	
180642...........	90	0.259	−0.035	0.031		−14	78 (V_G)	15, 39, 99	
		0.600	−0.110	0.140	2.636		15 (V)	101	
							17 (V)	101	
		0.670	−0.160	0.110	2.612		17 (V)	101	
		0.820	−0.180	0.170	2.625		9 (V)	101	
							34 (I)	102	
199140...........	60	−0.033	0.051	0.029	2.610	−8.5	85 (V)	1, 3, 63, 103, 104, 105	
203664...........	180					48	60 (V_G)	15, 39	
205021...........	25	−0.092	0.066	0.010	2.605	−3.1	37 (V)	2, 3, 106, 107, 108, 109	Spectroscopic binary; magnetic star; mild Be star; star is located in the overlap region of the BD and CD catalogs BD −22 4581=CD −22 12607
							29 (V)	110	
	45	−0.068	0.070	0.094		63	32 (V)	1, 38, 111, 112, 113	
214993...........	40	−0.034	0.052	0.050	2.609	−12.5	76 (y)	1, 3, 114, 115, 116, 117	Spectroscopic binary; star is located in the overlap region of the BD and CD catalogs BD −22 4581=CD −22 12607
216916...........	30	−0.047	0.066	0.092	2.629	−13	Var	1, 3, 118, 119, 120, 121	Spectroscopic binary; visual binary; eclipsing binary

Notes.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. Table 1 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

References.—(1) Cugier et al. 1994; (2) Lesh & Aizenman 1978; (3) Aerts & De Cat 2003; (4) Valtier et al. 1985; (5) Robb et al. 2000; (6) Pietrzynski 1997; (7) Pigulski et al. 2001; (8) Krzesiński et al. 1999; (9) Gomez-Forrellad 2000; (10) Krzesiński & Pigulski 1997; (11) Slettebak 1968; (12) Grady et al. 1987; (13) Jerzykiewicz et al. 1988; (14) Evans 1967; (15) De Cat et al. 2004; (16) De Cat et al. 2000; (17) Abt et al. 2002; (18) Wilson 1953; (19) Aerts et al. 2004a; (20) Handler et al. 2004; (21) Schrijvers et al. 2002; (22) De Mey et al. 1997; (23) Batten et al. 1989; (24) Telting et al. 2001; (25) Shobbrook 1973a; (26) Jakate 1979b; (27) Shobbrook 1985; (28) Heynderickx 1992; (29) Shobbrook 1973b; (30) Balona et al. 1992; (31) Irvine 1975; (32) Balona et al. 2002; (33) Balona 1995a; (34) Balona & Krisciunas 1994; (35) Duflot et al. 1995; (36) Sterken & Jerzykiewicz 1990; (37) Shobbrook 1981; (38) Heynderickx et al. 1994; (39) Aerts 2000; (40) Cousins 1982; (41) Handler et al. 2003; (42) Balona et al. 1997; (43) Balona 1977; (44) Feast 1958; (45) Balona 1994; (46) Engelbrecht 1986; (47) Freyhammer et al. 2004; (48) Kilkenny & Hill 1975; (49) Hill et al. 1974; (50) Gutierrez-Moreno & Moreno 1968; (51) Shobbrook 1979).; (52) Stankov et al. 2002; (53) Feast 1963; (54) Balona & Koen 1994; (55) Dachs & Kaiser 1984; (56) Schild 1970; (57) Hill 1970; (58) Waelkens & Heynderickx 1989; (59) Schrijvers et al. 2004; (60) Ausseloos et al. 2002; (61) Robertson et al. 1999; (62) Bernacca & Perinotto 1970; (63) Vander Linden & Sterken 1987; (64) Hill 1971; (65) Aerts et al. 2003; (66) Lloyd & Pike 1988; (67) Shobbrook 1972; (68) Telting & Schrijvers 1998; (69) Houk 1982; (70) Goosens et al. 1984; (71) Jerzykiewicz & Sterken 1984; (72) Chapellier & Valtier 1992; (73) Waelkens & Cuypers 1985; (74) Aerts et al. 1994; (75) Balona & Laney 1995; (76) Arentoft et al. 2001; (77) Balona 1983; (78) Balona & Shobbrook 1983; (79) Balona & Engelbrecht 1985a; (80) García & Mermilliod 2001; (81) Paardekooper et al. 2002; (82) Henroteau 1922; (83) Briers 1971; (84) Handler et al. 2005; (85) Shobbrook & Lomb 1972; (86) Lomb & Shobbrook 1975; (87) Uytterhoeven et al. 2001; (88) Jerzykiewicz 1993; (89) Jerzykiewicz 1972; (90) Kubiak & Seggewiss 1984; (91) Neiner et al. 2003; (92) J. Molenda-Żakowicz & G. Połubek 2005, in preparation; (93) Garrison et al. 1977; (94) Lynds 1959; (95) Jerzykiewicz 1975; (96) Cuypers et al. 1989; (97) Coté & van Kerkwijk 1993; (98) Balona 1995b; (99) Waelkens et al. 1998; (100)Waelkens et al. 1991) ; (101) Kołaczkowski et al. 2004a; (102) Pigulski & Kołaczkowski 1998; (103) Stankov et al. 2003; (104) Plaskett & Pearce 1931; (105) Aerts et al. 1995; (106) Frost 1906; (107) Pigulski & Boratyn 1992; (108) Telting et al. 1997; (109) Shibahashi & Aerts 2000; (110) Pigulski et al. 1997; (111) Waelkens & Rufener 1988; (112) Kilkenny & van Wyk 1990; (113) Dufton et al. 1998; (114) Young 1915; (115) Jerzykiewicz 1978; (116) Aerts 1996; (117) Dziembowski & Jerzykiewicz 1999; (118) Walker 1951; (119) Dziembowski & Jerzykiewicz 1996; (120) Thoul et al. 2003; (121) Jerzykiewicz & Pigulski 1999).

TABLE 2

Candidate β Cephei Stars

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Spectral Type (9)	V (mag) (10)	Reference (11)	Notes (12)
			NGC 663 114			01 46 40	+61 09 52	. . .	12.4	1	
13494..............		AG +56 243			V352 Per	02 13 37	+56 34 14	B1 III	9.3	2, 3	
14053..............			NGC 869 612	+56 498		02 18 23	+57 00 37	B1 II	8.5	2	
14250..............		AG +56 292		+56 545	V359 Per	02 20 16	+57 05 55	B1 IV	9.1	2	
		AG +57 301		+56 589	V360 Per	02 22 50	+57 30 42	B1 III	9.6	2	
21856..............	16518		1074	+34 674		03 32 40	+35 27 42	B1 V	5.9	4, 5	Not variable in 4; possible ζ Ophiuchi star
			NGC 1502 37			04 07 43	+62 19 39	B1.5 V	9.3	2, 6	
			NGC 150 26	+61 675		04 07 44	+62 10 04	B2 IV	9.6	6	
25638..............	19272		NGC 1502 1	+61 676A		04 07 51	+62 19 48	B0 III	6.9	6	
32990..............	23900		1659	+24 755	103 Tau	05 08 06	+24 15 55	B2 V	5.5	5	Spectroscopic binary
34656..............	24957			+37 1146		05 20 43	+37 26 19	O7e III	6.8	7, 8, 9, 10	
35149..............	25142	23 Ori	1770	+03 871		05 22 50	+03 32 40	B1 V	5.0	5, 11	Possible ζ Ophiuchi star
36166..............	25751		1833	+01 1032		05 29 55	+01 47 21	B2 V	5.7	5	Possible ζ Ophiuchi star
36512..............	25923	υ Ori	1855	−07 1106	36 Ori	05 31 56	−07 18 05	B0 V	4.6	12, 13, 14	
36695..............	26063	VV Ori	1868	−01 943		05 33 31	−01 09 22	B1 V	5.4	5, 11	Spectroscopic binary; possible ζ Ophiuchi star
36819..............	26248		1875	+23 954	121 Tau	05 35 27	+24 02 23	B2.5 IV	5.4	5, 11	Possible ζ Ophiuchi star
37756..............	26736		1952	−01 1004		05 40 51	−01 07 44	B2 IV–V	4.95	5	Spectroscopic binary
38622..............	27364		1993	+13 979	133 Tau	05 47 43	+13 53 59	B2 IV–V	5.27	5, 16	Double system with possible T Tauri component
39291..............	27658		2031	−07 1187	55 Ori	05 51 22	−07 31 05	B2 IV–V	5.3	5, 17, 18	Not variable in 18; possible ζ Ophiuchi star
40494..............	28199	γ Col	2106	−35 2612		05 57 32	−35 16 59	B2.5 IV	4.4	11, 16	Star in double system
252248............	29121	AG +13 539	NGC 2169 5		V917 Ori	06 08 27	+13 55 51	B2 V	8.8	2, 3, 19	Possible Be star
43078..............	29687	AG +22 667		+22 1243	LR Gem	06 15 15	22 18 04	B0 IV	8.8	2, 3	
44112..............	30073		2273	−07 1373	7 Mon	06 19 43	−07 49 23	B2.5 V	5.2	5, 11	Spectroscopic binary;; possible ζ Ophiuchi star
45546..............	30772		2344	−04 1526	10 Mon	06 27 57	−04 45 44	B2 V	5.04	5	Star in double system
51630..............	33447		2603	−22 1616		06 57 15	−22 12 10	B2 III/IV	6.6	20, 21	
53755..............	34234	ADS 5782 A	2670	−10 1862	V569 Mon	07 05 50	−10 39 36	B0.5 V	6.5	2, 22, 23, 24	
63949..............	38159	QS Pup	3058	−46 3460		07 49 12	−46 51 27	B1.5 IV	5.8	22, 25	
68324..............	39970	IS Vel	3213	−47 3653		08 09 43	−47 56 13	B2 IV	5.2	20, 22, 26	
69081..............	40321		3240	−35 4358	OS Pup	08 13 58	−36 19 20	B1.5 IV	5.1	11, 27	Possible ζ Ophiuchi star; in 27 slow variable
70839..............	40932		3293			08 21 12	−57 58 24	B1.5 III	5.9	11	Possible ζ Ophiuchi star
70930..............	41039	B Vel	3294	−48 3734		08 22 32	−48 29 25	B1 V	4.8	11	Double or multiple star; possible ζ Ophiuchi star
72108..............	41616		3358	−47 4004		08 29 05	−47 55 44	B2 IV	5.3	11	Double or multiple star
72127..............	41639		3359	−44 4462		08 29 28	−44 43 29	B2 IV	4.99	11	Double system; possible ζ Ophiuchi star
74071..............	42459	HW Vel	3440			08 39 24	−53 26 23	B5 V	5.4	21, 28	
74273..............	42614		3453	−48 4020		08 41 05	−48 55 22	B1.5 V	5.9	11	Double-lined spectroscopic binary; possible ζ Ophiuchi star
74455..............	42712	HX Vel	3462	−47 4251		08 42 16	−48 05 57	B1.5 Vn	5.5	11, 29	Susp. ell. var in 29; possible ζ Ophiuchi star
74575..............	42828	α Pyx	3468	−32 5651		08 43 36	−33 11 11	B1.5 III	3.7	21, 30, 31	IR standard star
74753..............	42834	D Vel	3476	−49 3761		08 43 40	−49 49 22	B0 IIIn	5.1	11	Possible ζ Ophiuchi star
86466..............	48799	IV Vel	3941	−52 3465		09 57 11	−52 38 20	B3 IV	6.1	27, 32	
89688..............	50684	RS Sex	4064	+03 2352	23 Sex	10 21 02	+02 17 23	B3.2 IV	6.6	3, 33, 34	$P_{Hipparcos} \sim 0.129$ day

TABLE 2—*Continued*

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Spectral Type (9)	V (mag) (10)	Reference (11)	Notes (12)
96446.........	54266	V430 Car		−59 3544		11 06 06	−59 56 59	B2 I He	6.7	35, 36	He strong
97533.........	54753			−57 3772		11 12 36	−58 38 38	B1:Vn	8.4	37	
					V770 Cen	11 21 09	−60 32 13	B5 e	12.4	38	Be star
			NGC 3766 67		V847 Cen	11 36 14	−61 37 36	B2 Vp	9.9	39	
104337.......	58587	TY Crv	4590	−18 3295	31 Crt	12 00 51	−19 39 32	B1.5 V	5.3	5, 40	Spectroscopic binary; ell. var. in 40
108483.......	60823	σ Cen	4743	−49 7115		12 28 02	−50 13 50	B2 V	3.9	11, 18	Possible ζ Ophiuchi star
112092.......	63003	μ1 Cru	4898			12 54 36	−57 10 41	B2 IV–V	3.9	11, 41	Double syst., not var. in 27 and 41
120307.......	67464	ν Cen	5190			13 49 30	−41 41 15	B2 V	3.4	42, 43, 44, 45, 46, 47	
121743.......	68245	ϕ Cen	5248	−41 8329		13 58 16	−42 06 03	B2 IV	3.8	17, 27, 48, 11, 49	Var. in 17, not var. in 27 and 48
121790.......	68282	υ01 Cen	5249	−44 9010		13 58 41	−44 48 13	B2 IV–V	3.8	11, 48, 49	Possible ζ Ophiuchi star; not var. in 48
132058.......	73273	β Lup	5571	−42 9853		14 58 32	−43 08 02	B2 III	2.7	42, 43, 50	Possible ζ Ophiuchi star
132200.......	73334	κ Cen	5576	−41 9342		14 59 10	−42 06 15	B2 IV	3.1	11, 49	
136504.......	75264	ϵ Lup	5708	−44 10066		15 22 41	−44 41 23	B2 IV–V	3.4	11, 49	Spectroscopic binary; possible ζ Ophiuchi star
142669.......	78104	ρ Sco	5928	−28 11714	5 Sco	15 56 53	−29 12 51	B2 IV–V	3.9	11, 45	Spectroscopic binary; possible ζ Ophiuchi star
142883.......	78168		5934	−20 4364		15 57 40	−20 58 59	B3 V	5.9	4, 45, 51	
143018.......	78265	π Sco	5944	−25 11228	6 Sco	15 58 51	−26 06 51	B1 V	2.9	11, 40, 45	Spectroscopic binary; ecl. bin in 40
144218.......	78821	β Sco A	5985	−19 4308		16 05 27	−19 48 07	B2 V	4.9	24, 42, 52, 53	
145502.......	79374	ν Sco	6027	−19 4333	14 Sco A	16 11 59	−19 27 39	B2 IV	4.13	11, 45, 54	Spectroscopic binary
148703.......	80911		6143	−34 11044	N Sco	16 31 23	−34 42 16	B2 III–IV	4.22	11, 18, 49	
149881.......	81362			+14 3086	V600 Her	16 36 58	+14 28 31	B0.5 III	7.0	34, 55, 56, 57	
151985.......	82545	μ2 Sco	6252	−37 11037		16 52 20	−38 01 03	B2 IV	3.5	11, 49	
326327.......		Braes 669	NGC 6231 28	−41 11007	V962 Sco	16 53 39	−41 47 48	B1.5 Ve+sh	9.7	58, 59	Triple system?
			NGC 6231 289	−41 11027p		16 54 06	−41 51 13	B0.5 V	9.5	60, 61	
			NGC 6231 80		V963 Sco	16 54 14	−41 55 01	B0 Vn	10.3	60, 61	
			NGC 6231 104			16 54 16	−41 49 34	. . .	10.2	61	
			NGC 6231 SBL 515	−41 7736		16 54 21	−41 49 30	B1 Vn	11.2	61	
163868.......	88123			−33 12700		17 59 56	−33 24 29	B5 Ve	7.4	37	Be star
171034.......	91014		6960	−33 13338		18 33 58	−33 00 59	B2 IV–V	5.3	11, 18, 49	Possible ζ Ophiuchi star
176502.......	93177	ADS 11910 A	7179	+40 3544	V543 Lyr	18 58 47	+40 40 45	B3 V	6.2	51	
			NGC 6871 14		V1820 Cyg	20 05 39	+35 45 31	B2 III	10.8	62	
		IC 4996 Hoag 7			V1922 Cyg	20 16 45	+37 40 44	. . .	10.9	4, 63, 64	
					V2190 Cyg	20 33 25	+41 22 04	. . .	14.3	65	
201819.......	104579		8105	+35 4426		21 11 04	+36 17 58	B0.5 IVn	6.5	4	
210808.......	109505			+62 2045	V447 Cep	22 11 00	+63 23 58	B5	7.3	66	
			NGC 7419 BMD 451			22 54 17	60 48 23	. . .	15.9	67, 68	Be star
			NGC 7419 BMD 551			22 54 19	60 48 14	. . .	16.4	67, 68	Be star
217035.......		KZ Cep		+62 2136		22 56 31	+62 52 07	B0 V	7.7	2, 69	Maybe Be star

Notes.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. Table 2 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

References.—(1) Pigulski et al. 2001; (2) Hill 1967; (3) Kukarkin et al. 1971; (4) Jerzykiewicz 1993; (5) Telting et al. 2002; (6) Delgado et al. 1992; (7) Balona 1975; (8) Balona et al. 1992; (9) Fullerton et al. 1991; (10) Balona 1995b; (11) Schrijvers et al. 2002; (12) Waelkens 1991; (13) Balona & Engelbrecht 1985b; (14) Smith 1981; (15) Li & Hu 1998; (16) Gerbaldi et al. 2001; (17) Kukarkin et al. 1981; (18) Adelman 2001; (19) Jerzykiewicz et al. 2003; (20) Jerzykiewicz & Sterken 1977; (21) Balona 1977; (22) Wilson 1953; (23) Shobbrook 1983; (24) Abt et al. 2002; (25) Heynderickx et al. 1994; (26) Sterken & Jerzykiewicz 1993; (27) Jakate 1979b; (28) Renson & Sterken 1977; (29) Morris 1985; (30) Sterken & Vander Linden 1983; (31) Van Hoof 1973a; (32) Evans 1967; (33) Percy & Au-Yong 2000; (34) De Cat et al. 2004; (35) Matthews & Bohlender 1991; (36) Mathys 1994; (37) J. Molenda-Żakowicz & G. Połubek 2005, in preparation; (38) Vidal et al. 1974; (39) Balona & Engelbrecht 1986; (40) Kazarovets et al. 1999; (41) Pedersen & Thomsen 1977; (42) Duflot et al. 1995; (43) Aerts & De Cat 2003; (44) Gutierrez-Moreno & Moreno 1968; (45) Levato et al. 1987; (46) Cuypers et al. 1989; (47) Schrijvers & Telting 2002; (48) Balona 1982; (49) Sterken & Jerzykiewicz 1983; (50) Schrijvers 1999; (51) Koen & Eyer 2002; (52) Aerts et al. 1999; (53) Holmgren et al. 1997; (54) Van Hoof et al. 1963; (55) Morris 1985; (56) Antokhina & Barannikov 1996; (57) Hill et al. 1976; (58) Balona & Laney 1995; (59) García & Mermilliod 2001; (60) Balona & Engelbrecht 1985a; (61) Arentoft et al. 2001; (62) Delgado et al. 1984; (63) Delgado et al. 1985; (64) Hoag et al. 1961; (65) Pigulski & Kołaczkowski 1998; (66) Koen 2001; (67) Beauchamp et al. 1994; (68) Kołaczkowski et al. 2002; (69) Deupree 1970.

TABLE 3

Poor and Rejected β Cephei Candidates

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Spectral Type (9)	V (mag) (10)	References (11)	Notes (12)
3379................	2903	53 Psc	155	+14 76	AG Psc	00 36 47	15 13 54	B2.5 IV	5.9	1, 2	SPB star
				+61 285		01 32 37	+61 58 12	B0.5 III:	9.5	3	$P \sim 2$ days, aliasing mistake in reference
13051..............	10541	V351 Per		+55 554		02 09 26	+56 59 30	B1 IV:	8.6	4, 5	$P_{Hipparcos} \sim 2.5$ days
13544..............	10391	AG +53 218	+53 480		V353 Per	02 13 52	+53 54 53	B0.5 IV	8.9	6, 7, 8	
			NGC 869 49	+56 473	V356 Per	02 16 58	+57 07 49	B0.5 IIIn	9.2	4, 7, 9	Be star; claimed variability not confirmed
		NSV 776	NGC 869 963		Oo 963	02 18 58	+57 08 18	B2 IV	11.0	10	Claimed variability not confirmed
13745..............		AG +55 231			V354 Per	02 15 46	+55 59 47	O9.7 II	7.9	7, 11	No convincing variability in *Hipparcos* photometry
13831..............	10615			+56 469	V473 Per	02 16 39	+56 44 16	B0 IIIp	8.3	12	
13866..............	10641	V357 Per		+56 475		02 16 58	+56 43 08	B2 Ib	7.5	4, 7	Claimed variability not confirmed
15239..............	11604		St7−28	+60 487	V528 Cas	02 29 38	+60 39 26	B2.5 V+sh	8.5	13	$P_{Hipparcos} \sim 1$ day
15752..............	11953	AG +58 273		+57 589	V362 Per	02 34 12	+58 24 20	B0 III	8.8	7	No convincing variability in *Hipparcos* photometry
16429A...........	12495	STF 284A		+60 541	V482 Cas	02 40 45	+61 16 56	O9.5 III	7.9	7, 14	
19374..............	14514	53 Ari	938	+17 493	UW Ari	03 07 26	17 52 48	B1.5 V	6.1	15, 16, 17	Claimed variability not confirmed
23480..............	17608	Merope	1156	+23 522	V971 Tau	03 46 20	+23 56 54	B6 IVe	4.2	18, 19, 20	Periodic Be star, $P = 0.49$ day
24640..............	18434	NSV 1418	1215	+34 768		03 56 29	+35 04 51	B1.5 V	5.5	21, 22	
27396..............	20354	53 Per	1350	+46 872	V469 Per	04 21 33	+46 29 56	B4 IV	4.8	23, 24	SPB star
28114..............	20715		1397	+08 687	V1143 Tau	04 26 21	+08 35 25	B6 IV	6.1	25	SPB star
28446..............	21148	DL Cam	1417	+53 779	1 Cam	04 32 01	+53 54 39	B0 IIIn	5.8	26, 27	Probably SPB
33328..............	23972	λ Eri	1679	−08 1040	69 Eri	05 09 09	−08 45 15	B2 IVne	4.2	8, 20, 28, 29	Periodic Be star, $P = 0.702$ day
35468..............	25336	γ Ori	1790	+06 919	24 Ori	05 25 08	+06 20 59	B2 III	1.6	30, 31	
37776..............	26742			−01 1005	V901 Ori	05 40 56	−01 30 26	B2 IV	6.9	7, 32, 33	
38010..............	26998			+25 941	V1165 Tau	05 43 39	25 26 22	B1 Vpe	6.8	34	Be star, $P_{Hipparcos} \sim 0.67$ day
252214............	29106	AG +13 535	NGC 2169 2	+13 1120	V916 Ori	06 08 18	13 58 18	B2.5 V	8.1	5, 7, 35	Claimed variability not confirmed
43837..............	30041	AG +20 661		+20 1369		06 19 17	+20 34 48	B2 Ibp. . .	8.5	6, 36	$P_{Hipparcos} \sim 2$ days
43818..............	30046	LU Gem		+23 1300	11 Gem	06 19 19	+23 28 10	B0 II	6.9	36, 37, 38	
47432..............	31766		2442	+01 1443	V689 Mon	06 38 38	+01 36 49	O 9.5 III	6.2	6, 39, 40	$P_{Hipparcos} \sim 2$ days
51309..............	33347	ι CMa	2596	−16 1661	20 CMa	06 56 08	−17 03 15	B3 Ib/II	4.4	2, 41, 42	
53974..............	34301	FN CMa	2678	−11 1790		07 06 41	−11 17 39	B0.5 IV	5.4	5, 7, 39	$P_{Hipparcos} \sim 1$ day
55857..............	34924	GY CMa	2734	−27 3789	ALS 255	+07 13 36	−27 21 23	B0.5 V	6.1	37, 43, 44	Claimed variability not confirmed
55958..............	34937	GG CMa	2741	−30 4143		07 13 47	−03 01 51	B2 IV	6.6	45, 46	Claimed variability not confirmed
57219..............	35406	υ02 Pup	2790	−36 3519	NW Pup	07 18 39	−36 44 34	B2 IVne	5.1	47, 48, 49	
65575..............	38827	χ Car	3117			07 56 47	−52 58 57	B3 IVp	3.4	8, 16, 41, 50	
67536..............	39530		3186	−62 330	V375 Car	08 04 43	−62 50 11	B2.5 Vn	6.2	8, 37, 51	Be star, $P_{Hipparcos} = 1.01646$ days
74195..............	42536	o Vel	3447			08 40 18	−52 55 19	B3 IV	3.6	52	SPB star

TABLE 3—*Continued*

HD (1)	*Hipparcos* (2)	Name (3)	HR/Cluster (4)	BD/CD (5)	Other Name (6)	R.A. (J2000) (7)	Decl. (J2000) (8)	Spectral Type (9)	V (mag) (10)	References (11)	Notes (12)
74375..........	42568	d Car	3457	−59 2020	V343 Car	08 40 37	−59 45 40	B1.5 III	4.3	6, 51, 53	$P_{Hipparcos} = 2.37952$ days
74280..........	42799	η Hya	3454	+03 2039	7 Hya	08 43 14	+03 23 55	B3 V	4.9	41, 54, 55	$P_{Hipparcos} \sim 2.2$ days
77002..........	43937	b01 Car	3582	−58 2347	V376 Car	08 56 58	−59 13 45	B2 IV–V	4.9	37, 56, 57	Claimed variability not confirmed
77320..........	44213	IU Vel	3593	−42 4875		09 00 22	−43 10 26	B2.5 Vne	6.1	19, 20, 47	Periodic Be star ($P = 0.612$ day)
85953..........	48527		3924	−50 4622	V335 Vel	09 53 50	−51 08 48	B2 III	5.9	52	SPB star
92007..........			NGC 3293 26	−57 3350	V379 Car	10 35 59	−58 14 15	B1 III	8.2	20, 58, 59, 60, 61	Periodic Be star ($P = 1.754$ days)
98410..........	55207	ALS 2299		−62 505	V536 Car	11 18 18	−62 58 28	B2/B3 Ib/II	8.8	26	$P_{Hipparcos} = 1.45325$ days
104841........	58867	θ^2 Cru	4603	−62 610		12 04 19	−63 09 57	B2 IV	4.7	37, 41	
106490........	59747	δ Cru	4656	−58 4466		12 15 09	−58 44 56	B2 IV	2.8	16, 39, 41, 62, 63, 64	
109668........	61585	α Mus	4798	−68 1104		12 37 11	−69 08 08	B2 IV–V	2.7	16, 37, 39, 41	
		BT Cru	NGC 4755 418	−59 4542		12 53 36	−60 23 46	B2 V	9.6	64, 65, 66, 67, 68	Claimed variability not confirmed
			NGC 4755 215			12 53 38	−60 22 49		11.6	58, 69, 70	$P = 0.355$ day, SPB star?
		BV Cru	NGC 4755 105			12 53 39	−60 21 12	B0.5 IIIn	8.7	65, 67, 68	$P \sim 1$ or 2 days, possible binary
112078........	63007	λ Cru	4897	−58 4794		12 54 39	−59 08 48	B4 Vne	4.6	5, 20, 47, 62, 71	$P_{Hipparcos} = 0.35168$ day, $Q = 0.11$ day
116072........			5034	−60 4639	V790 Cen	13 22 36	−60 58 19	B2.5 Vn	6.2	8, 72	β Lyr-type eclipsing binary
122980........	68862	χ Cen	5285	−40 8405		14 06 03	−41 10 47	B2 V	4.4	57	
130903........	72710	He 3−1034		−40 9037	V1018 Cen	14 51 58	−40 48 21	B2p	7.9	26, 73, 74	
160762........	86414	ι Her	6588	+46 2349	85 Her	17 39 28	+46 00 23	B3 IV	3.8	75, 76	
160124........	86432		NGC 6405 100	−32 13072	V994 Sco	17 39 38	−32 19 13	B3 IV	7.2	77, 78	SPB star
180125........	94588			+10 3839	V1447 Aql	19 14 58	+10 24 34	B8 V	7.4	26, 74	$P_{Hipparcos} = 2.1678$ days
180968........	94827	ES Vul	7318	+22 3648	2 Vul	19 17 44	+23 01 32	B0.5 IV	5.4	8, 20, 79	Periodic Be star ($P = 1.27$ days)
188439........	97845		7600	+47 2945	V819 Cyg	19 53 01	+47 48 28	B0.5 IIIn	6.3	6, 79	
189687........	98425	25 Cyg	7647	+36 3806	V1746 Cyg	19 59 55	+37 02 34	B3 IVe	5.1	80, 81	Be star
195556........	101138	ω^1 Cyg	7844	+48 3142	45 Cyg	20 30 04	+48 57 06	B2.5 IV	4.9	27	
204076........	105912	BR Mic		−32 16569		21 27 01	−31 56 20	B2 II	8.8	82	$P_{Hipparcos} \sim 3.6$ days
217811........	113802	LN And	8768	+43 4378		23 02 45	+44 03 32	B2 V	6.4	83	
224559........	118214	LQ And	9070	+45 4381	AG +46 2225	23 58 46	46 24 47	B4 Vne	6.5	20, 84, 85	Periodic Be star ($P = 0.619$ day)

Notes.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds. Table 3 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

References.—(1) Le Contel et al. 2001; (2) Kukarkin et al. 1981; (3) Maciejewski et al. 2004; (4) Mahra & Mohan 1979; (5) Kukarkin et al. 1971; (6) Koen & Eyer 2002; (7) Hill 1967; (8) Grady et al. 1987; (9) Steele et al. 1999; (10) Krzesiński et al. 1999; (11) De Cat et al. 2004; (12) Garrido & Delgado 1982; (13) Percy & Madore 1972; (14) McSwain 2003; (15) Percy & Au-Yong 2000; (16) Adelman 2001; (17) Sterken 1988; (18) McNamara 1985; (19) Balona 1990; (20) Balona 1995a; (21) Jones 1960; (22) Telting et al. 2002; (23) De Ridder et al. 1999; (24) Chapellier et al. 1998; (25) Mathias et al. 2001; (26) Kazarovets et al. 1999; (27) Jerzykiewicz 1993; (28) Balona 1975; (29) Balona 1995b; (30) Krisciunas & Luedeke 1996; (31) Krisciunas 1994; (32) Catalano & Renson 1998; (33) Khokhlova et al. 2000; (34) Jaschek et al. 1980; (35) Jerzykiewicz et al. 2003; (36) Percy 1984; (37) Jakate 1979b; (38) Shobbrook 1978; (39) Balona 1977; (40) Balona & Engelbrecht 1981; (41) Elst 1979b; (42) Balona & Engelbrecht 1985b; (43) Breger et al. 1991; (44) Balona & Cuypers 1993; (45) Jerzykiewicz & Sterken 1977; (46) Morris 1985; (47) Balona et al. 1992; (48) Yudin 2001; (49) Dachs et al. 1981; (50) Leone & Catanzaro 1998; (51) Van Hoof 1973b; (52) Aerts et al. 1999; (53) Waelkens & Rufener 1983a; (54) Abt et al. 2002; (55) Saxena & Srivastava 1997; (56) Jakate 1979a; (57) Balona 1982; (58) Balona et al. 1997; (59) Cugier et al. 1994; (60) Duflot et al. 1995; (61) Feast 1958; (62) Shobbrook 1981; (63) Elst 1979a; (64) Schrijvers et al. 2002; (65) Balona & Koen 1994; (66) A. Stankov 2005, in preparation; (67) Jakate 1978; (68) Koen 1993; (69) Stankov et al. 2002; (70) Perry et al. 1976; (71) Evans 1967; (72) Waelkens & Rufener 1983b; (73) Dachs & Kaiser 1984; (74) ESA 1997; (75) Mathias & Waelkens 1995; (76) Chapellier et al. 2000; (77) Waelkens 1991; (78) Waelkens & Rufener 1985; (79) Lynds 1959; (80) Percy et al. 2002; (81) Pavlovski et al. 1997; (82) Hambly et al. 1994; (83) Shaw et al. 1983; (84) Matthews et al. 1991; (85) Percy & Lane 1977.

TABLE 4

Pulsation Periods for Stars from Table 1

Identifier (1)	Period (days) (2)	Reference, (Note) (3)
HD 886	0.1517502ps	1
V909 Cas	0.207p	2
NGC 663 4	0.194047p	3
V611 Per	0.1716946p	4
V665 Per	0.242342p	5
	0.199545p	This work
	+more	
V614 Per	0.1326359p	5
NGC 884 2246	0.184188p	6
	0.170765p	
V595 Per	0.31788p	6
HD 16582	0.1611ps	s: 7, p: 8
HD 21803	0.201779ps	9, 10
	0.198085ps	10, 11
	0.227099p	10, 11
	+more	10
HD 24760	0.1887s	12
	0.1698s	
	0.1600s	
	0.1455s	
	0.13976s	s: 13, not found in 12
	0.1911s	s: 13, not found in 12
HD 29248	0.1735126ps	14
	0.1768681ps	
	0.1779337ps	
	0.1773937ps	
	0.126619ps	
	0.16015ps	
	0.15969ps	
	0.16074s	
	0.1389p	
HD 35411	0.133s	15
HD 35715	0.0954s	16
	0.0932s	
HD 44743	0.2512988ps	p: 17, s: 18, rv: 19
	0.25003ps	17, 18, 20, rv: 19
	0.23904ps	17, rv: 19, 21
HD 46328	0.2095754p	22
HD 50707	0.18464ps	22
	0.1932ps	23
	0.1924p	
HD 52918	0.191207ps	24
	0.204517ps	
HD 56014	0.0919p	p: 25
HD 59864	0.238p:	26
	0.243p:	
HD 61068	0.166385p	22
	0.164921p	
HD 64365	0.201584p	This work
	+ more	
HD 64722	0.11541p	27
	0.1168 or 0.1323p	
HD 71913	0.20578p	28
HD 78616	0.21569ps	18, 22
HD 80383	0.18316p	29
	0.18647p	
	0.1847p	
HD 90288	0.10954p	29
	0.12024p	
	0.10344p	
	0.1295p	
HD 303068	0.1457p	30
	0.1487p	

TABLE 4—*Continued*

Identifier (1)	Period (days) (2)	Reference, (Note) (3)
HD 303067	0.1684p	30; similar situation as for HD 303068
	0.1751p	
	0.1643p	
V403 Car	0.251p	30; similar situation as for HD 303068
V412 Car	0.114p:	30
V404 Car	0.16p:	30
V405 Car	0.152p	30
	0.158p	
	0.1841p:	22
V378 Car	0.1600p	30
	0.2070p	
	0.177p:	
V440 Car	0.179p:	31
V406 Car	0.1756p	30; similar situation as for HD 303068
	0.1785p	
V380 Car	0.2274p	30
V381 Car	0.1773p	30
	0.1502p	32
	0.1397p	32
HD 109885	0.17054p	29
	0.16806p	
	0.1616p	
	0.1752p	
HD 111123	0.1911846ps	33
	0.1678228ps	34
	0.1827430ps	
BS Cru	0.151p	35
	0.156p	
	0.163p	
	0.137p	
	0.157978p	36
NGC 4755 113	0.233p	37
NGC 4755 405	0.125p	35
	0.128p	
CT Cru	0.131p	35
CV Cru	0.179p	35
	0.128p	
CZ Cru	0.159p	35
	0.108p	
	0.1386p	30
CX Cru	0.182p	35
CY Cru	0.159p	37
NGC 4755 210	0.093p	35
BW Cru	0.205p	35
	0.220p	
	0.190p	
	0.1623p	36
HD 112481	0.254537p	22
	0.259618p	
HD 116658	0.173787ps	38
HD 118716	0.169608ps	39, 40
	0.17696ps	40, 41
	0.1617s	
	0.1356s	
	0.1308s	
HD 122451	0.153496s	42
	0.155920s	(Balona's photometric period uncertain)
	0.153960s	
HD 126341	0.17736934ps	43
HD 129056	0.25984663ps	22
	0.2368ps	44

TABLE 4—*Continued*

Identifier (1)	Period (days) (2)	Reference, (Note) (3)
HD 129557	0.1275504ps	45
	0.142516p	46
	0.134769p	
HD 129929	0.1547581p	47
	0.1433013p	
	0.1550486p	
	0.1430527p	
	0.1517234p	
	0.1435509p	
HD 136298	0.198ps	39, 48
HD 144470	0.067s	49
HD 145794	0.15991p	50
	0.1918p	
HD 147165	0.246829ps	51
	0.239661ps	
HD 147985	0.132312ps	52
	0.144930ps	18
	0.156656ps	
V945 Sco	0.06706p	53
V1032 Sco	0.11928p	54
	0.07699p	
	0.12040p	
V946 Sco	0.09878p	53
	0.09544p	
	0.09071p	
	0.08550p	
	0.08302p	
V964 Sco	0.087846p	54
	0.067575p	
	0.055328p	
V947 Sco	0.10788p	53
	0.06096p	
V920 Sco	0.10119p	53
	0.10765p	
	0.10389p	
	0.12137p	
	0.09114p	
HD 156327B	0.146p	55
	0.136p	
HD 156662	0.16890p	52
	0.18861p	
	0.16978p	
HD 157056	0.1405280ps	56
	0.13722p	
	0.13569p	
	0.13391p	
	0.12877p	
	0.12699p	
	0.12542p	
HD 157485	0.2212p	28
	0.2240p	
HD 158926	0.2138272ps	57
	+ more	
HD 160578	0.19983ps	57
HD 163472	0.13989010ps	10, 58
	0.1466s	10, 59
HD 164340	0.1529341p	60
	0.1567948	60
HD 165174	0.303ps	10, 61
HD 165812	0.1759p	28
	0.2180p	
HD 166540	0.23299p	62
	0.22729p	
HD 180642	0.18225ps	10, 28

TABLE 4—*Continued*

Identifier (1)	Period (days) (2)	Reference, (Note) (3)
NGC 6910 18	0.156539p	63
	0.162486p	
	0.148877p	
NGC 6910 16	0.192198p	63
	0.171077p	
	0.239556p	
NGC 6910 14	0.190396p	63
NGC 6910 27	0.143010p	63
V2187 Cyg	0.25388p	64
HD 199140	0.20104444ps	65, 66
HD 203664	0.16587ps	10, 28
	+more	10
HD 205021	0.1904870ps	67
	0.2031s	68
	0.1967s	
	0.1859s	
	0.18460s	
NGC 7235 8	0.202890p	69
	0.177898p	
HN Aqr	0.15231ps	70, 71
HD 214993	0.23583ps	72
	0.19738ps	73
	0.19309ps	
	0.1917p	
	0.1884p	
	0.18747ps	
	0.18215ps	
	0.1711p	
	0.1350p	
HD 216916	0.1691670ps	74
	0.1708555ps	75
	0.1817325ps	
	0.1816843p	

Notes.—The letter "p" after a given period denotes a photometric detection and "s" denotes a spectroscopic one. Uncertainties of the periods are in the last digits. Table 4 is also available in machine-readable form in the electronic edition of the *Astrophysical Journal Supplement*.

References.—(1) Valtier et al. 1985; (2) Robb et al. 2000; (3) Pigulski et al. 2001; (4) Krzesiński et al. 1999; (5) Gomez-Forrellad 2000; (6) Krzesiński & Pigulski 1997; (7) Campos & Smith 1980; (8) Cugier & Nowak 1997; (9) Jarzebowski et al. 1981; (10) De Cat et al. 2004; (11) Struve & Zebergs 1959; (12) De Cat et al. 2000; (13) Gies et al. 1999; (14) De Ridder et al. 2004; (15) De Mey et al. 1996; (16) Telting et al. 2001; (17) Shobbrook 1973a; (18) Aerts et al. 1994; (19) Struve 1950; (20) Balona et al. 1996; (21) Kubiak 1980; (22) Heynderickx 1992; (23) Lynds et al. 1956; (24) Balona et al. 2002; (25) Balona & Krisciunas 1994; (26) Sterken & Jerzykiewicz 1990; (27) Sterken & Jerzykiewicz 1980; (28) Aerts 2000; (29) Handler et al. 2003; (30) Balona et al. 1997; (31) Balona 1994; (32) Freyhammer et al. 2004; (33) Cuypers et al. 2002; (34) Aerts et al. 1998; (35) Stankov et al. 2002; (36) Koen 1993; (37) Balona & Koen 1994; (38) Lomb 1978; (39) Shobbrook 1972; (40) Schrijvers et al. 2004; (41) Schrijvers 1999; (42) Ausseloos et al. 2002; (43) Cuypers 1987; (44) Mathias et al. 1994a; (45) Vander Linden & Sterken 1985; (46) Sterken & Jerzykiewicz 1983; (47) Aerts et al. 2004b; (48) Lloyd & Pike 1988; (49) Telting & Schrijvers 1998; (50) Waelkens & Heynderickx 1989; (51) Chapellier & Valtier 1992; (52) Waelkens & Cuypers 1985; (53) Balona & Shobbrook 1983; (54) Balona & Engelbrecht 1985a; (55) Paardekooper et al. 2002; (56) Handler et al. 2005; (57) Lomb & Shobbrook 1975; (58) Kubiak & Seggewiss 1984; (59) Neiner et al. 2003; (60) J. Molenda-Żakowicz & G. Połubek 2005, in preparation; (61) Cuypers et al. 1989; (62) Waelkens et al. 1991; (63) Kołaczkowski et al. 2004a; (64) Pigulski & Kołaczkowski 1998; (65) Aerts et al. 1995; (66) Sterken et al. 1993; (67) Telting et al. 1997; (68) Stebbins & Kron 1954; (69) Pigulski et al. 1997; (70) Kilkenny & van Wyk 1990; (71) Dufton et al. 1998; (72) G. Handler et al. 2005, in preparation; (73) Mathias et al. 1994b; (74) Lehmann et al. 2001; (75) Jerzykiewicz & Pigulski 1999.

boundary decreases to 0.036 day). Assuming twice the photometric period as the rotation period of a possible rotationally variable star, we derive a rotational velocity of $\sim$800 km s^{-1}. This value is higher than the break-up velocity and excludes the possibility of rotational variability. Therefore, V595 Per is confirmed to be a β Cephei star.

HD 24760 (ϵ Per).—Preliminary results by K. Uytterhoeven (2004, private communication) on this star show that several frequencies are probably excited in ϵ Per and that harmonics are also present. More research on this star is currently in progress. See also Harmanec (1999) and Gies et al. (1999).

HD 35715 (ψ^2 Ori).—Is also an ellipsoidal variable. Pulsation was not detected photometrically but in line profiles.

HD 52918 (19 Mon).—This is also a Be star (Hα emission discovered by Irvine (1975)) with a relatively high pulsation amplitude that may be connected to shock phenomena in the atmosphere. Balona et al. (2002) find three frequencies, two of them are due to β Cephei-type pulsation.

HD 56014 (27 (BW) CMa).—Balona (1995a) lists this star as a periodic Be star with a period of $P = 1.262$ days. Short-period pulsations were, however, detected by Balona & Krisciunas (1994), who report the redetection of a period of $P = 0.0918$ day. Next to HD 52918, this would be the second star to exhibit Be as well as β Cephei type variability. It is also a close optical double system, and therefore it is possible that the β Cephei variability does not originate in the Be star. More research on this star is needed.

HD 122451 (β Cen).—Very eccentric double-lined spectroscopic binary with two β Cephei components.

HD 158926 (λ Sco).—This is a triple system with a variable dominant period of around 4.679410 cycles day^{-1}. There are three additional significant frequencies that can, however, be attributed to either the primary or the tertiary component of this system (Uytterhoeven et al. 2004a, 2004b).

HD 160578 (κ Sco).—K. Uytterhoeven (2004, private communication) confirms one pulsation mode at 4.99922 cycles day^{-1}, together with its first harmonic. All other additional frequencies mentioned in the literature can be explained by means of a rotational modulation effect between a nonradial mode and the rotation of the star in presence of spots on the stellar surface, but a pure nonradial pulsation model cannot be excluded at the time being (Harmanec et al. 2004).

HD 165174 (V986 Oph).—This is by far the hottest, most massive and most luminous β Cephei star; it also has one of the longest periods. The nature of this mild Be star has been discussed in detail by Cuypers et al. (1989), and we agree with these authors that there is no compelling reason not to consider it a β Cephei star. It satisfies our definition of this group of pulsating stars.

8.3. *Notes on Individual Candidate β Cephei Stars*

NGC 1502 37.—According to Delgado et al. (1992), Hill (1967) confused this star with NGC 1502 A=NGC 1502 1. We give its correct identification here and note in addition that NGC 1502 37 is a visual binary.

HD 34656.—This O7e III star was investigated by Fullerton et al. (1991), who detected radial velocity variations with a period of 8.81 hr, of which we are however not convinced. Fullerton et al. (1991) inferred that HD 34656 is a pulsating star and excluded the possibilities of the variations originating in rotational modulation of a weak surface feature or motion in a binary system. They associated its variability with β Cephei type pulsation but were reluctant to identify it as such a variable at that time. This star is often cited to be the only O-type β Cephei star pulsator, despite the authors' caution.

HD 36512 (ν Ori).—Although the periods claimed for this star in the literature imply SPB-like variability, our amplitude spectrum of its *Hipparcos* data has the highest peak at a period of 0.146 day indicating a β Cephei nature of the pulsation.

HD 43078.—Hill (1967) suggests the presence of a fairly convincing 0.23887 day period for this star, which is, however, not present in the *Hipparcos* data. The Strömgren colors of this star are unusual, placing it considerably below the ZAMS, and are inconsistent with its spectral classification.

HD 53755 (V569 Mon).—Balona (1977) found a period of 0.18 day. In the *Hipparcos* data we could not detect any convincing periodicity. The highest peak in the amplitude spectrum of these data is at 0.66 day, which is too long for β Cephei type pulsation.

HD 63949 (QS Pup).—There are doubts about the presence of the 0.1182 day variation in the 1975 data set as well as about the 0.108 day variation (C. Sterken 2003, private communication). The *Hipparcos* amplitude spectrum for this star indicates no variability exceeding 4 mmag.

HD 74455.—Morris (1985) suspected it to be an ellipsoidal variable; confirmed in *Hipparcos* data (this work); see also Waelkens & Rufener (1983a).

HD 74575 (α Pyx).—Van Hoof (1973a) concluded from RV measurements that this star is a β Cephei variable; Balona (1977) found it not variable in RV, whereas Sterken & Vander Linden (1983) found a well-defined sinusoidal velocity curve with a probable period of 5 hr, but from one night only.

HD 86466 (IV Vel).—The available data are not conclusive. Jakate (1979b) places this star in his "suspected β Cephei stars" table. The highest peak in the amplitude spectrum of the *Hipparcos* data of the star is at a 0.105 day period, but a 0.55 day variation is almost equally probable.

HD 96446 (V430 Car).—This Bp star shows a 0.8514 day period resulting from rotation, but a possible secondary period near 0.26 day could be due to pulsation (Matthews & Bohlender 1991).

NGC 3766 67 (V847 Cen).—The frequency of the light variation of this candidate β Cephei star is close to 4 cycles per sidereal day, which could indicate an extinction problem, and low-frequency variability also seems to exist.

HD 104337.—Ellipsoidal variability is confirmed by *Hipparcos* data (this work).

HD 120307 (ν Cen).—This is a single-lined spectroscopic binary and a Be star; see Cuypers et al. (1989). The period of 0.4255 day results in $Q = 0.107$ day, which is too large for β Cephei pulsation. Most of the other periods found for this star are too long for β Cephei pulsation as well. Schrijvers & Telting (2002), however, detected seven frequencies spectroscopically that they attributed to high degree modes ($\ell > 5$), which could be connected to β Cephei type pulsation or be ζ Ophiuchi-like line profile variability.

HD 143018.—Ellipsoidal variable with $P = 1.570$ day, see Stickland et al. (1996).

HD 144218 (β Sco A).—Binary system; β Cep candidate with a tentative period of $P = 0.1733$ day (see Holmgren et al. 1997).

HD 149881 (V600 Her).—Possibly an ellipsoidal variable with a β Cephei component (De Cat et al. 2004). Pulsational variability not detectable in *Hipparcos* data within a limit of 4.5 mmag.

HD 176502 (V543 Lyr).—Visual double star. The *Hipparcos* data clearly indicate that the star is variable, but the timescale remains unknown because of aliasing; it could be either several days or 2.5 hr.

NGC 6871 14 (V1820 Cyg).—Few variability measurements of this candidate β Cephei star are available, and the star is underluminous for the rather longperiod claimed.

HD 210808 (V447 Cep).—The analysis of this star's *Hipparcos* photometry reveals a primary period of 0.314 day, and a possible secondary period of 0.460 day (Koen 2001). The late spectral type of the star is inconsistent with its Strömgren Hβ index (2.639), suggesting a possible Be nature. The star is also known as a visual binary and as an X-ray source.

8.4. *Notes on Individual Rejected β Cephei Stars*

HD 13544 (V353 Per).—Two periods of 0.6647 and 0.7724 day explain this star's *Hipparcos* photometry.

HD 13831 (V473 Per).—Be star. Published data indicate short-period variability, but *Hipparcos* photometry (this work) fails to confirm that.

HD 16429A (V482 Cas).—This star is a speckle binary in a triple system; also a radio emitter and an X-ray source. Timescales present in its *Hipparcos* light curves are of the order of $P = 1.7$–2.5 days.

HD 24640.—The published radial velocity curves are not convincing. Variability timescales in the star's *Hipparcos* photometry are longer than 1.5 days.

HD 28446 (1 (DL) Cam).—Our analysis of this star's *Hipparcos* photometry results in candidate periods considerably longer than those of β Cephei type pulsation; it is also possible that parts of eclipses were observed by the satellite.

HD 35468 (γ Ori).—Krisciunas (1994) and Krisciunas & Luedeke (1996) suspect this is a low-amplitude, possibly irregular variable. However, their measurements are too scarcely sampled to enable a search for periods in the range of β Cephei pulsations.

HD 37776 (V901 Ori).—This is a rapidly rotating magnetic CP star (Catalano & Renson 1998). We determine a period of 1.538 days from its *Hipparcos* photometry.

HD 43818 (11 (LU) Gem).—Most recent data (Percy 1984) show no evidence for variability on a timescale <0.2 day but on a timescale of >0.2 day or more likely >0.5 day. The period derived in that paper is $P = 1.25$ days. Period from *Hipparcos* $\sim$2.1 days (this work).

HD 51309 (ι CMa).—There are no new data since the work of Balona & Engelbrecht (1985b). In their work the star was defined as a 53 Per star with a tentative period of 1.3947 days.

HD 57219 (ν02 Pup).—Our analysis of this star's *Hipparcos* data shows little evidence for variability, contrary to the suggestion of low-signal variability by Balona et al. (1992). The spectral classification of the star is also a matter of debate (see Dachs et al. 1981). Renson et al. (1991) classify the star as B3 and He strong, which seems to be the classification most consistent with its Strömgren colors.

HD 65575 (χ Car).—The *Hipparcos* light curves show no evidence for variability within a limit of 3 mmag.

HD 104841 (θ^2 Cru).—Claimed to be an ultra–short-period pulsator (Jakate 1979b), but not confirmed. The *Hipparcos* photometry is consistent with a double-wave light variation with a period of 3.4 days.

HD 106490 (δ Cru).—Variability dubious, and if present, of long period (3.6 days). *Hipparcos* photometry shows no variability above 3 mmag.

HD 109668 (α Mus).—Variability dubious, and if present, of long period. *Hipparcos* photometry shows no variability above 2.5 mmag. Radial velocity variable.

HD 122980 (χ Cen).—No short-period light variations. The *Hipparcos* data indicate possible slower low-amplitude variability (this work). Radial velocity variable.

HD 130903 (V1018 Cen).—The *Hipparcos* data can be folded with a period of 1.65064 days to give a double-wave light curve. Although only few measurements are available, we suspect the star is a binary-induced variable.

HD 160762 (ι Her).—Slowly pulsating B star with suspected, but unconfirmed shorter period variations. Cannot be considered to be a β Cephei star for the time being.

HD 188439 (V819 Cyg).—The *Hipparcos* period of this OB runaway star is 0.71373 day, resulting in $Q = 0.10$ day.

HD 195556 (ω^1 Cyg).—The available data, including the *Hipparcos* photometry indicate several possible or unstable periods, all of which are, however, longer than 15 hr.

HD 217811 (LN And).—Claimed to be an ultra–short-period pulsator, but not confirmed. A three-day period explains the variations in the *Hipparcos* photometry.

8.5. *Notes on Individual Frequencies*

HD 24760 (ϵ Per).—A period at 0.0945 day was detected by Smith et al. (1987) as well as Gies et al. (1999). We assume that this is a harmonic of the main pulsation mode at $P = 0.1887$ day.

HD 35411 (η Ori).—A period at 0.43208 day was found by Waelkens & Lampens (1988) in their photometric data. It is doubtful if it originates from pulsation.

HD 52918 (19 Mon).—A period at 5.88 days was also detected (Balona et al. 2002), which is too long for β Cephei-type pulsation.

HD 59864 (V350 Pup).—Sterken & Jerzykiewicz (1990) demonstrated the multiperiodicity of this star, but could not give unambiguous period determinations because of aliasing. The choice of the primary frequency also affects all others. The periods we list are the most likely ones from the work by Sterken & Jerzykiewicz (1990).

HD 61068 (PT Pup).—Heynderickx (1992) reports two frequencies that we list in Table 4. This author, however, noted aliasing problems in his period determinations. Amplitude variability also seems present. In addition, the *Hipparcos* data for this star (Koen & Eyer 2002) do not confirm the periodicities listed by Heynderickx (1992). More observations of this star are clearly necessary to determine the periodic content of its variability properly.

HD 64365 (QU Pup).—Frequency analyses by Sterken & Jerzykiewicz (1980) and Heynderickx (1992) had periods of 0.1678 and 0.1927 day in common. However, our analysis of the *Hipparcos* photometry of that star resulted in a 0.2016 day period, which is the 1 cycle day^{-1} alias of the 0.1678 day period given by the previous authors. As we suspect that the prewhitening of this erroneous period from single-site data had generated spurious secondary signals, we only list the frequency found in the *Hipparcos* data. We do point out that the star is multiperiodic in any case.

HD 64722 (V372 Car).—Aliasing mistake by Heynderickx (1992), solved by reanalysis of *Hipparcos* data, this work.

HD 78616 (KK Vel).—There may be another independent pulsation mode at half the period we listed.

HD 303068.—Different authors list up to five different frequencies (see Engelbrecht 1986; Heynderickx 1992), of which only two are in common in the different studies.

V404 Car.—Additional periods of 0.1742 and 0.1506 day are listed by Engelbrecht (1986), but they were not confirmed by other work.

HD 111123 (β Cru).—More frequencies are possibly present, but we are unsure whether they originate from pulsation (Cuypers et al. 2002).

HD 116658 (α Vir).—The only periodicity that we regard convincing in the analyses of this star is 0.1738 day. Smith (1985) found a number of additional signals in his line-profile analysis. We support the suggestion by Aerts & De Cat (2003) that more spectroscopic data have to be analyzed before a definite conclusion about the presence of the additional periodicities can be made.

HD 136298 (δ Lup).—Photometric period likely an alias of the spectroscopic one quoted.

HD 145794 (V349 Nor).—The value of the second period of this star is uncertain because of aliasing (Waelkens & Heynderickx 1989).

HD 156327B (V1035 Sco).—The V amplitude is 35 mmag; spectroscopic variability was detected, but no period could be determined.

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