HIPPARCOS VERSUS GCVS AMPLITUDES OF NON-MIRA M-TYPE GIANTS

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Abstract

A recent paper by Dumm and Schild deals with the determination of radii and masses for Hipparcos stars with non-Mira giant M-type spectra. Their list contains 350 stars, of which 205 are either verified or suspected variables, including 53 SR (semiregular) and 51 Lb (irregular) variables. The authors determined that the masses and radii of the non-variable stars show a clear correlation, whereas the variable stars deviate from this relation roughly according to their amplitudes. In comparing the Hipparcos amplitudes with the amplitudes in the GCVS and NSV I found numerous conspicuous discordances, ranging well over a whole magnitude. I therefore hoped that the older amplitudes, based in general upon data more specifically obtained for period determination, might improve the scatter in the Dumm and Schild diagram, but this is not the case. In the course of the investigation, numerous stars were encountered that merit further observations. Two were found of especial interest: V370 And, discovered by Hipparcos, and λ Dra, with a reputed period of 1100 days.

1. Distribution of the M-type giants

A recent publication by Dumm and Schild (1998) dealing with the determination of radii and masses of non-Mira M-type giants observed by Hipparcos gives Hipparcos amplitudes of 350 stars. I have checked these against the *General Catalogue of Variable Stars* (GCVS) (Kholopov *et al.* 1985–87; Samus 1990), the *New Catalogue of Suspected Variable Stars* (NSV) (Kholopov *et al.* 1982), and the *Name Lists of Variable Stars*, Nos. 67–73 (Kholopov *et al.* 1985; Kholopov *et al.* 1987; Kholopov *et al.* 1989; Kazarovets and Samus 1990, 1995, 1997; Kazarovets *et al.* 1993), as well as *The Hipparcos and Tycho Catalogues* (ESA 1997). Of the 350 stars, 205 are either named or suspected variables. Table 1 summarizes the distributions of the 350, of which 53 are SR and 51 Lb types. One star, β Gru, classified Lc, has ambiguous data. According to the GCVS, Lc applies to supergiants, whereas the generally quoted spectral class

Table 1. Summary of the 350 stars.

	No.	*Variable Types*	*No.*
Named Variables	118	Lb	51
NSV	87	Lc	1
Not Known to be Variable	145	SR	53
Total	350	I	2
		cst	3
		Types Undetermined	95
		Total Variable	205

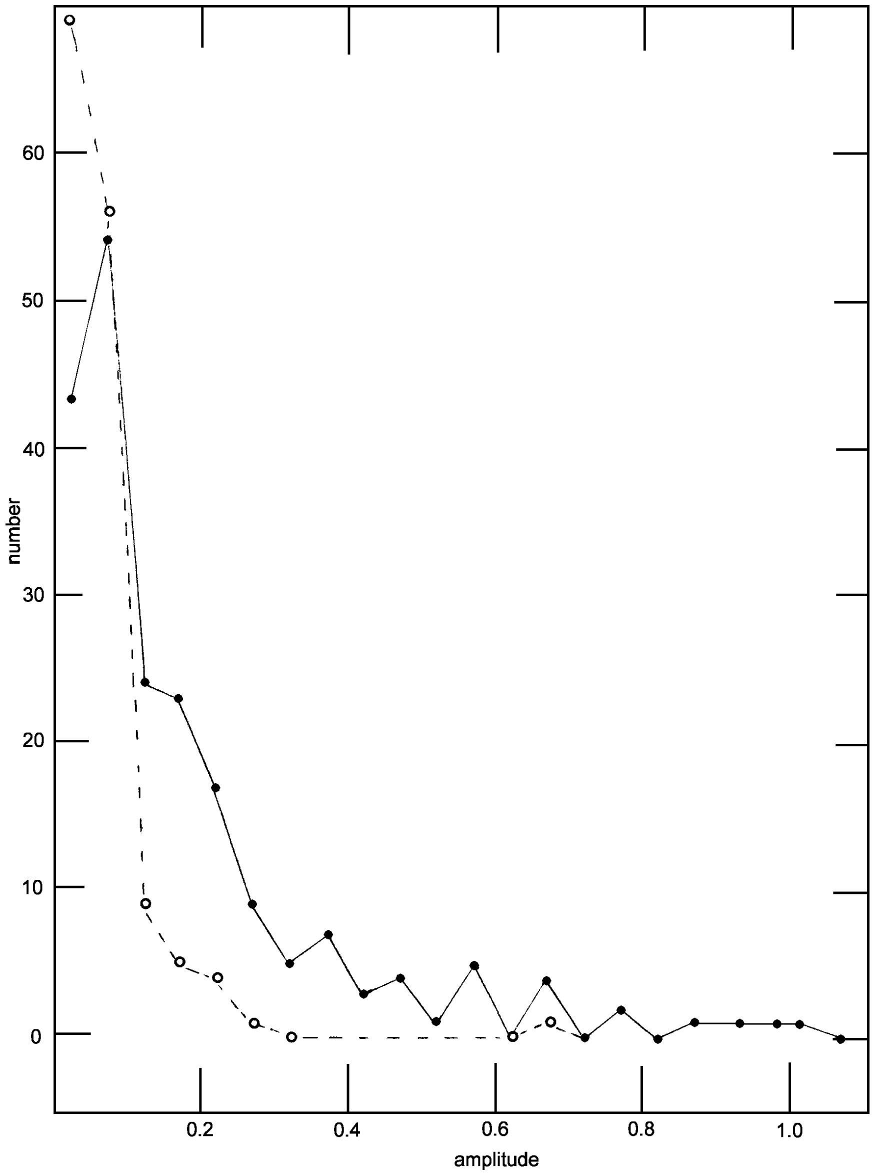

Figure 1. Frequency distributions of Hipparcos amplitudes of confirmed (GCVS) or suspected (NSV) variables (dots); and of presumably non-variable stars (open circles). Data plotted in this figure are listed in Table 5.

applies to a normal giant, M5III, sometimes M3II, while the absolute magnitude based on a trigonometric parallax of 0".0068 yields an uncertain supergiant absolute magnitude of –3.8. Similarly another star, RS Cnc, classified SRc (a supergiant according to the GCVS) is quoted by Dumm and Schild as having spectral class M6S but is classified in the GCVS as M6eIb-II(S).

The two plots in Figure 1 give the frequency distributions of the stars listed by Dumm and Schild that have been either confirmed or suspected of variability, and those that are still presumably constant, as they have not heretofore been reported as variable. Table 5 shows the data from which the plots in Figure 1 (and Figure 3) were plotted.

2. Comparison of GCVS and Hipparcos amplitudes

In many cases the visual amplitudes are larger than the amplitudes obtained by Hipparcos. The Hipparcos magnitudes are not V, as in the UBV system, but are close to it. The authors state that their list excludes stars with amplitudes greater than 1.05 magnitudes on the Hipparcos system. However, 13 of their stars do have larger amplitudes in the GCVS, from1.10 to 3.6V. The relation between the amplitudes in the two determinations is shown in Figure 2. (The diagram does not include stars for which the GCVS amplitude is photographic, not visual.) The diagonal at the lower part of the diagram indicates what would have been complete agreement between the two amplitude systems. All of the points deviating from this line by over 0.7V correspond to SR type variables. The amplitudes determined by Hipparcos spanned little over three years. As the amplitudes for successive cycles may not be constant, part of the discrepancies may arise from this cause. The frequencies of the Hipparcos and GCVS amplitudes for the SR and Lb types are shown in Figure 3, except that 14 SR stars with GCVS amplitudes greater than 1.0V are omitted from the lower plot. (These stars all have much smaller Hipparcos amplitudes.) Otherwise the GCVS frequency distributions for the SR and Lb type variables are similar. Data shown in Figure 3 are listed in Table 5.

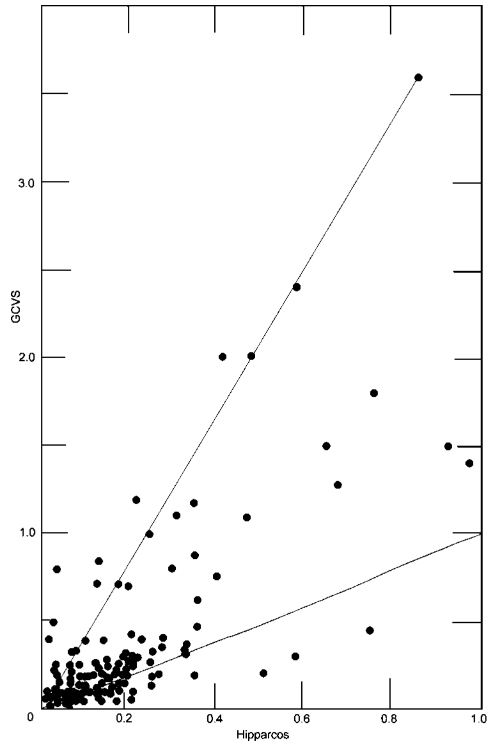

Figure 2. Hipparcos vs GCVS magnitude amplitudes. Lower diagonal line indicates complete agreement; the upper diagonal, the trend of the most discordant amplitudes.

3. Radius and mass relationships

Figure 4 gives the frequency-distributions of the radii determined by Dumm and Schild for the SR and Lb stars. The radii for the SR stars show two maxima, at about 130

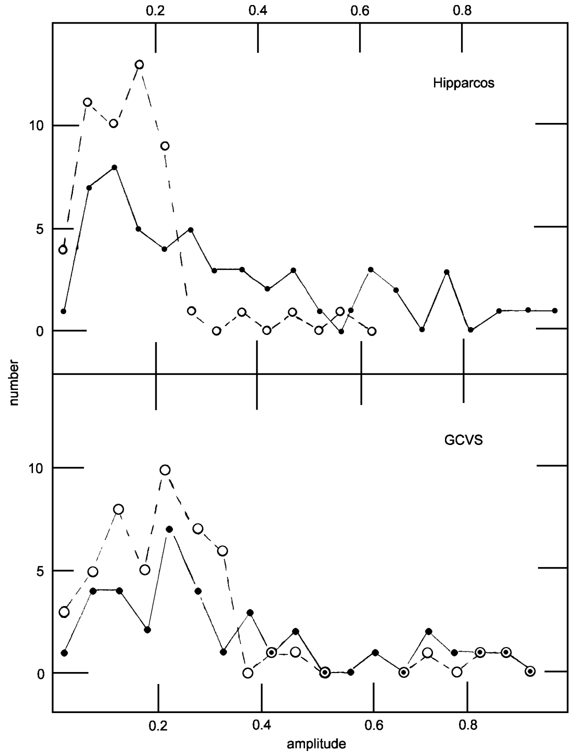

Figure 3. Frequency distributions of the amplitudes of SR (dots) and Lb type variables (open circles). The upper graph is for Hipparcos amplitudes, the lower for data from the GCVS. The lower graph omits 14 SR stars with amplitudes far exceeding those in Hipparcos. Their V amplitudes range from 1.0 to 3.6.

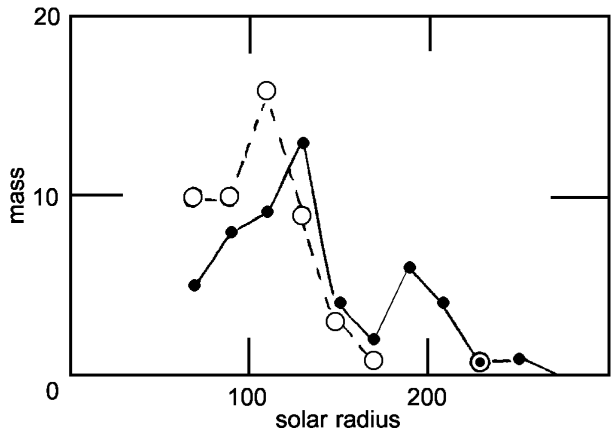

Figure 4. Frequency distributions of stellar radii determined by Dumm and Schild for SR- (dots) and Lb- (open circles) type variables.

Table 2. Stars with largest discrepancies in amplitude (GCVS – Hip).

No.	*Name*	*Hip*	*GCVS*	*Diff.*	*Type*	*Period*	*Radius*	*Mass*	*Hip.No.*
54	R Dor	0.76	1.8	1.0	SRb	338:	208	1.5	21479
60	RX Lep	0.59	2.4	1.8	SRb	60:	186	2.3	24169
91	L_2 Pup	0.86	3.6	2.7	SRb	140.6	126	1.7	34922
201	θ Aps	0.45	2.2p		SRb	119	196	1.9	68815
233	g Her	0.48	2.0	1.5	SRb	89.2	215	2.7	80704
235	TX Dra	0.59	2.3p		SRb	78:	109	1.8	81188
303	V1070 Cyg	0.42	2.0	1.6	SRb	73.5	123	1.1	105562
310	V1339 Cyg	0.22	1.2	1.0	SRb	35	135	2.3	107140

and 190 solar radii. The Lb types show a maximum at 110 and only a single questioned Lb type with a radius larger than 170 (θ Aps, radius 226).

The distributions of the masses are shown in Figure 5. Here there is no significant difference between the distributions of the SR and Lb types.

4. Mass, radius, amplitude, and period relations

Dumm and Schild have indicated a clear relation between mass and radius for non-variable stars, and shown that the variables deviate from this relation roughly in accordance with their photometric amplitudes. It is therefore of interest to examine those variables whose visual or photographic amplitudes are larger than the Hipparcos amplitudes by amounts exceeding the likely errors of the visual or photographic (0.5 for visual; photographic amplitudes are assumed to be approximately twice the visual). Table 2 gives data on the eight stars (all SRb) that show the greatest discrepancies between the GCVS and the Hipparcos amplitudes, the GCVS being the larger in all cases. In contrast, the stars in Table 3 have larger, and presumably more accurate, amplitudes in Hipparcos than the GCVS or NSV. However, all are within the natural uncertainties of the GCVS V-magnitudes. (As yet no definitive periods are available for these.)

The star with the largest amplitude in the Dumm and Schild list is a variable newly discovered by Hipparcos (Hip. No. 9234) with an amplitude of 1.01 magnitudes. It has been named V370 And. The somewhat sparcely distributed 88 observations on 27 days, spanning a little over three years, suggest a 240-day SR period (Hoffleit 1998). As yet no visual observations are available. More data are needed. The star is HD 11979 at $01^h58^m44.29^s$ +44°26'07.3" (2000), 7.37V, M4III, more likely an SR than the Hipparcos-assigned I type.

For all of the variable stars listed by Dumm and Schild Table 4 gives the relation between mean GCVS amplitudes and corresponding radii. These values are plotted in

Table 3. Stars with larger amplitudes in Hipparcos than GCVS.

No.	*Name*	*Hip*	*GCVS*	*Diff.*	*Type*	*Period*	*Radius*	*Mass*	*Hip.No.*
35	TV Hor	0.26	0.15	-0.11	SRb	30	115	2.2	11648
163	V919 Cen	0.58	0.3	-0.3	SR		239	2.2	57607
166	FR Cam	0.21	0.05	-0.16	L		87	2.1	58545
246	V2113 Oph	0.51	0.22	-0.29	SR:		68	1.6	84780
324	ν Tuc	0.27	0.18	-0.09	Lb:		63	1.2	111310

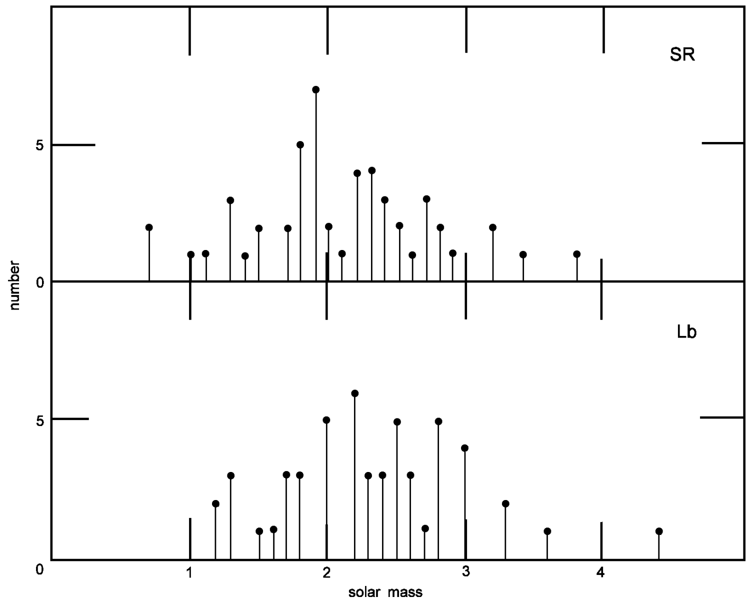

Figure 5. Frequency distributions of Dumm and Schild determinations of stellar masses. Upper graph for SR; lower for Lb types.

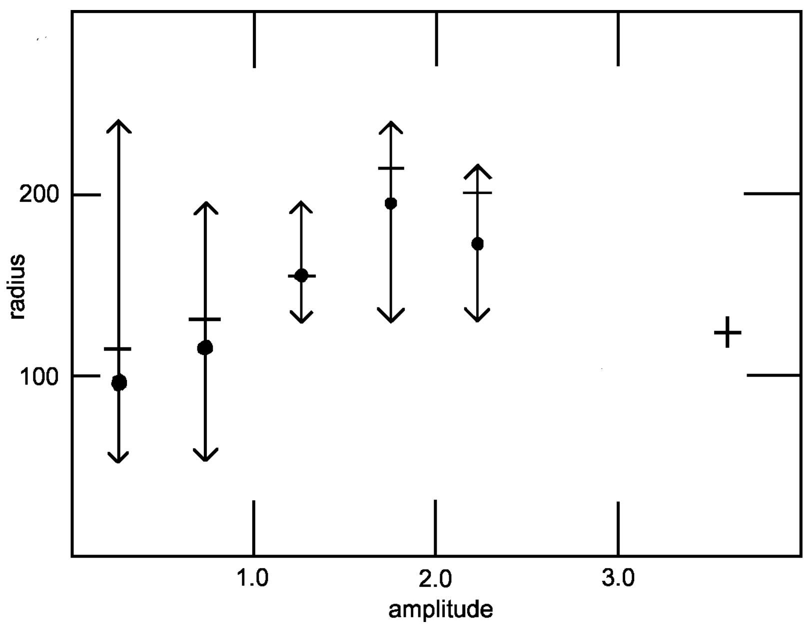

Figure 6. Relation between the V-amplitudes (GCVS) and radii of the variables in Dumm and Schild (1998). The arrows indicate the maximum spread of the radii. The crosses indicate the averages for SR only.

Table 4. Radius-to-amplitude relation.

Amplitude (GCVS)		*No.*	*Radius*	
Mid	*Range*		*Range*	*Ave.*
0.25	0.00–0.49	158	30–226	93
0.75	0.50–0.99	10	45–198	118
1.25	1.00–1.49	7	135–200	153
1.75	1.50–1.99	4	130–248	195
2.25	2.00–2.49	3	123–215	175
3.6		1		126

Figure 6. Statistically there is an average trend for the larger amplitudes to correspond to larger radii, as Dumm and Schild have indicated. Limiting the relation to the SR stars only (crosses in Figure 6) does not change the results significantly. However, the large dispersions in radius suggest that the amplitude cannot be used as a reliable criterion for estimating a stellar radius.

The relation between the periods and masses of the SR stars is shown in Figure 7. For periods less than 200 days there appears to be a statistical trend, the shorter periods on average having the larger masses. Two stars appear to deviate significantly from the trend: OP Her, 120.5 days, mass 3.4; and V806 Cen, 12 days, mass 1.3.

5. An unusual star, λ Draconis

An exceptional star, λ Dra (NSV 5231), is not included in Figure 7: mass 2.2, tentative published period 1100 days. Jackisch (1963) gives a plot (Figure 8) with only 14 points in a span of approximately 1900 days showing two maxima separated by about 1100 days. Although he states that observations over a two-day interval give no indication of a short period, he does not call attention to his first three early observations which suggest the possibility of a much shorter period than 1100 days. If real, the early maximum shortly after JD 2434800 is some 750 days prior to the central maximum on his graph, not consistent with the 1100-day separation of the two primary maxima.

The Hipparcos catalogue contains 125 observations which John Lee has plotted for me (Figure 9). These observations indeed suggest that there may be a double cycle of about 1100 days, the two maxima not being equally spaced (intervals approximately 650 + 450 = 1100 days). However, there is considerable scattering of the observations, with one outstanding minimum (JD 2448976) occurring just before rise to maximum. Within the overall scattering of the Hipparcos observations, Jackisch's are consistent with the Hipparcos double cycle light curve. Jackisch's have been fitted to the Hipparcos data by a period of 1100 days (Figure 10). The Hipparcos catalogue lists the star as variable type I. It may actually be a type SRb. In view of the large scattering in the relatively more accurate Hipparcos data, the 1100-day period may either be spurious, or the star varies in multiple periods. More work is clearly desirable.

6. Conclusion

In conclusion, a comparison between Hipparcos amplitudes and earlier visual estimates for non-Mira-type M-giant stars has revealed a number of questions that merit further investigation. Will future more precise and intensive observations of many of the SRb type variables confirm or refute the crude statistical correlations found between their amplitudes and radii (Figure 6), and between their masses and periods (Figure 7)?

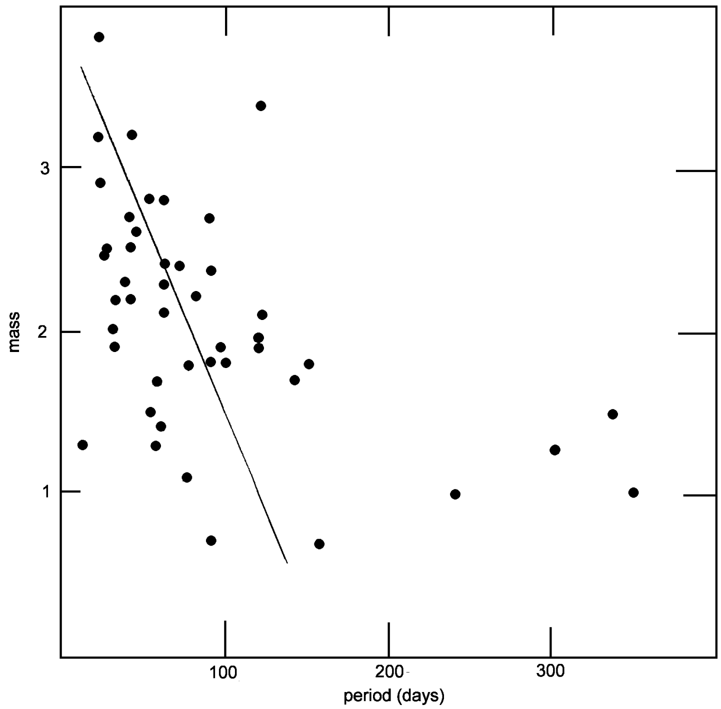

Figure 7. Relation between the periods of SR type variables and the Dumm and Schild determinations of stellar masses. A general trend for periods under 200 days is indicated. The two discordant points are for OP Her, 120.5d, mass 3.4; and V806 Cen, 12d, mass 1.3. Not plotted is λ Dra, tentative period 1100 days, mass 2.2.

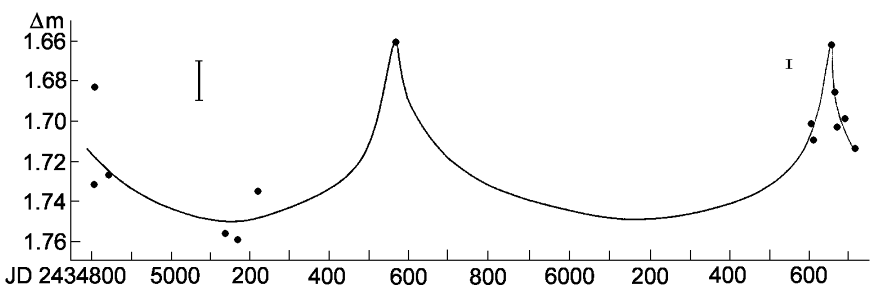

Figure 8. Jackisch's observations of λ Dra, his basis for a 1100-day period. Observations approximately 1954 through 1959.

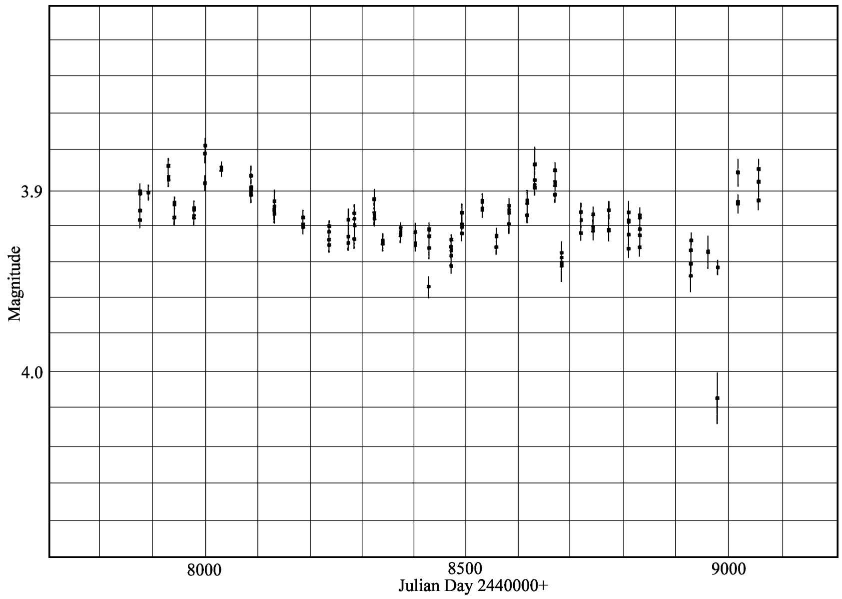

Figure 9. Hipparcos observations for λ Dra, with vertical markers indicating the observational errors.

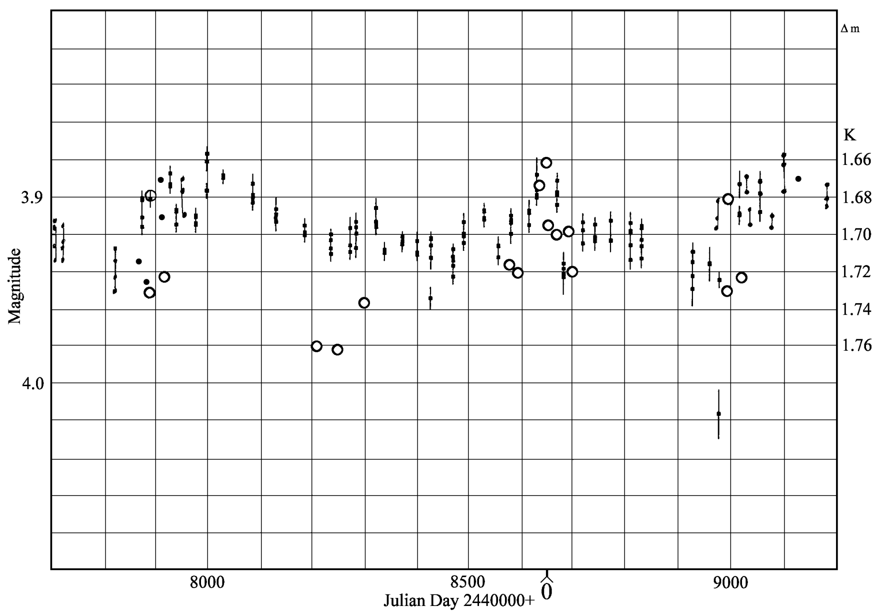

Figure 10. The Jackisch observations of λ Dra have been fitted to a 1100-day period and, with an arbitrary change of zero point (indicated on the x-axis), have been superposed (open circles) on the Hipparcos observations.

Table 5. Stars in Dumm and Schild confirmed or suspected of variability, or still presumed constant.

	Hipparcos				GCVS	
Amp	*All Var*	*Non Var*	*SR*	*Lb/c*	*SR*	*Lb*
0.00–0.04	43	69	1	4	1	3
0.05–0.09	54	56	7	11	4	5
0.10–0.14	24	9	8	10	4	8
0.15–0.19	23	5	5	13	2	5
0.20–0.24	17	4	4	9	7	10
0.25–0.29	9	1	5	1	4	7
0.30–0.34	5	0	3	0	1	6
0.35–0.39	7	0	3	1	3	0
0.40–0.44	3	0	2	0	1	1
0.45–0.49	4	0	3	1	2	1
0.50–0.54	1	0	1	0	0	0
0.55–0.59	5	0	0	1	0	0
0.60–0.64	0	0	3	0	1	0
0.65–0.69	4	1	2	0	0	0
0.70–0.74	0	0	0	0	2	1
0.75–0.79	2	0	3	0	1	0
0.80–0.84	0	0	0	0	1	1
0.85–0.89	1	0	1	0	1	1
0.93	1	0	1	0	0	0
0.98	1	0	1	0	0	0
1.01	1	0	0	0	0	0
Others					14	0
Photographic	5				4	2
Total	210	145	53	51	53	51

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