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GSC 03949-00386 IS A DOUBLE-MODE HIGH-AMPLITUDE δ SCUTI STAR

BERNHARD, K.[1,4]; SRDOC, G.[2]; FRANK, P.[3,4]

[1] A–4030 Linz, Austria; e-mail: klaus.bernhard@liwest.at

[2] Sarsoni 90, Viskovo, Croatia; email: gregor@vip.hr

[3] D–84149 Velden; email: frank.velden@t-online.de

[4] Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V. (BAV), Munsterdamm 90, D–12169 Berlin, Germany

GSC 03949-00386 (2MASS J20194496+5829200, 1SWASP J201944.95+582920.0) ($\alpha_{2000} = 20^h19^m44^s95$; $\delta_{2000} = +58°29'19''9$) was detected as a short period variable in the SuperWasp database (http://www.superwasp.org, Butters et al., 2010).

The star has $V = 10.82$ and $B - V = 0.553$ transformed from the Tycho-2 catalogue (Høg et al., 2000), the Tycho Input Catalogue, revised version gives $V = 11.00$ (Egret et al., 1992), the 2MASS catalogue gives $J - K = 0.167$ (Cutri et al., 2003). The average SuperWasp magnitude (~ 11.1 mag) differs from the V magnitude derived from Tycho-2 significantly. This can be explained by the different passbands, because SuperWasp uses a wide band V filter (CV).

GSC 03949-00386 was monitored by the authors from observatories in Germany (seven nights between JD 2 455 829 and JD 2 455 851) and Croatia (one night: JD 2 455 837).

The instruments used were a Teleview 509/5.0 telescope equipped with a Sigma 1603 CCD camera with −IR filter (PF), and a Meade 12" LX200 telescope with a CV filter and a SBIG ST-7XME CCD camera (GS).

For the decision, if the combination of these three data sets with somewhat different passbands is feasible, they were first analyzed separately (Period04, Lenz and Breger, 2005). The differences of the semiamplitudes of the fundamental period between the three sets were at most 0.003 mag. This is in the range of the calculated uncertainties (sigmas) of about 0.001 mag for the semiamplitudes of the single data sets. Therefore it is possible to combine these data sets applying a shift for different mean magnitudes.

The differential magnitudes of our telescopes were shifted to fit the SuperWasp magnitudes. The data are available electronically through the IBVS website as 6013-t1.txt.

Our observations combined with the SuperWasp data showed that GSC 03949-00386 is a pulsating variable with a total amplitude of about 0.25 mag and two peaks in the periodogram, at 10.440179 c/d (period: 0.095783796 d) and 13.524850 c/d (period: 0.073937974 d) (Fig. 1).

Using the Fourier analysis program, other significant peaks at linear combinations of the main frequencies were found as well, see Table 1 for an overview.

The Fourier graph after prewhitening for the frequencies given in Table 1 is shown in Fig. 2.

Table 1. Frequencies detected in GSC 03949-00386

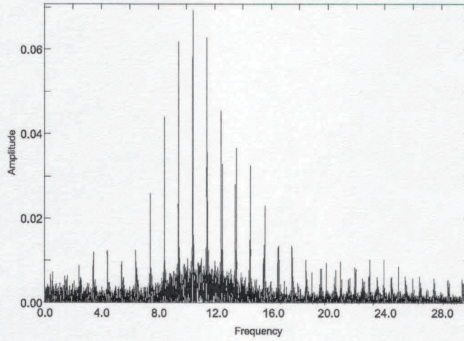| Mode	Frequency (c/d)	Semi-amplitude (mag)
f_0	10.440179 ± 0.000001	0.069
f_1	13.524850 ± 0.000002	0.035
$f_0 + f_1$	23.965029 ± 0.000006	0.010
$2f_0$	20.880358 ± 0.000007	0.009

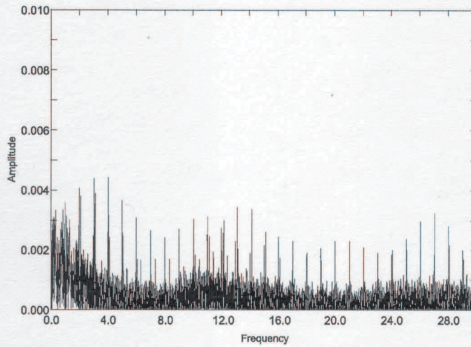**Figure 1.** Fourier graph between 0 and 30 c/d

Figure 2. Fourier graph after prewhitening the detected frequencies of Table 1
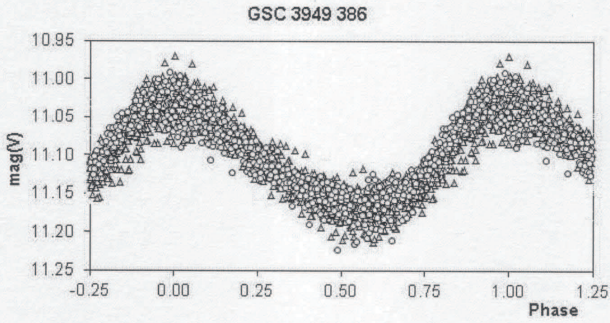
Figure 3. Phase plot for the fundamental period of 0.095783796 days, after prewhitening for the first overtone period.
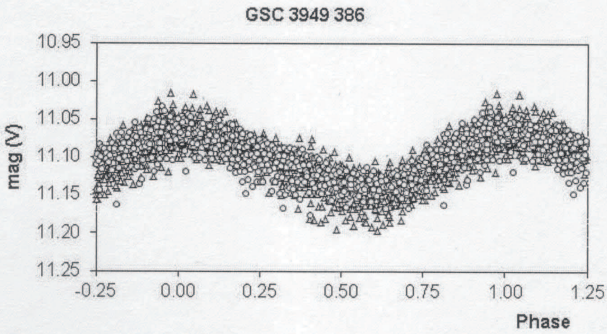

Figure 4. Phase plot for the first overtone period of 0.073937974 days, after prewhitening for the fundamental period and its first harmonic.

The remaining peaks emerge about integer frequency values, which is likely to originate from instrumental effects and atmospheric extinction.

Folded light curves for these periods, after prewhitening for the other, are given in Figs. 3 and 4.

CV filtered data are represented with open circles, −IR data with open triangles. The ratio between these periods is 0.7719257 ± 0.0000002, which makes this star a member of the rare group of radially pulsating double-mode HADS (e.g. Petersen and Christensen-Dalsgaard, 1996).

The proper motion of GSC 03949-00386 is small, $-8.8\,\mathrm{mas/y}$ in RA and $-9.9\,\mathrm{mas/y}$ in declination, according to the UCAC2 Bright Star Supplement catalog (Urban et al., 2006). Together with the relatively long period, this makes it an unlikely candidate to be an SX Phe star, but rather a Population I object. The classification HADS is also supported by the $B - V$ value derived from the Tycho-2 catalogue.

GSC 03949-00386 fits well to the period ratios clustering around 0.772 for $\log P_0 = -1.0$ found for other double mode HADS (Poretti et al., 2005).

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