MULTIPERIODICITY IN LIGHT VARIATIONS OF 53 PERSEI: RESULTS FROM OPTICAL PHOTOMETRY IN 1990 OCTOBER –1991 JANUARY

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1. Introduction

The B type star 53 Persei was discovered in 1977 by Smith (1977) as the prototype of a separate group of B-type variables showing light and line profile variability. The physical cause of the variability was thought to be nonradial pulsation (NRP) (see, e.g. Smith et al. 1984). However, the NRP model for this star has been questioned by Balona (1986) who suggested the rotational modulation (RM) model to explain the variability. In order to resolve the long lasting debate about 53 Persei, a campaign was initiated to organize coordinated optical photometry and spectroscopy from the ground, and Far-UV photometry from Voyager in 1991 January. This paper presents the results of period analysis on the groundbased *UBV* data. In another paper, Smith & Huang (1994) report the new identification of pulsation modes using Voyager Far-UV photometry combined with the results from optical observations. Some preliminary results from APT *uvby* observations taken at a single site are also cited for comparison.

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2. Observation and data reduction

Four observatories (Beijing in China, Braeside in U.S.A., Hvar in Croatia, and Konkoly in Hungary) participated in the campaign. Two A type stars, 47 Persei and HR 1482, were adopted as comparison and check star, respectively. All observations were corrected for atmospheric extinction and transformed to the standard UBV system. The observational uncertainties estimated from the standard deviations of the check star measurements are 0.011, 0.012, and 0.020 mag for V, B and U, respectively. The $uvby$ measures were made using the 0.75 m Automatic Photoelectric Telescope (APT) of the Four College Consortium. The same comparison and check stars were used. The data were reported as the differential magnitudes between 53 Persei and the comparison. The standard deviations of the check minus comparison measures were 0.009, 0.008, 0.010, and 0.008 mag for u, v, b, and y, respectively.

3. Period analysis and results

We first calculated the clean spectra of data using a CLEAN algorithm (Roberts, Lehár, & Dreher 1987) and then, taking the frequencies at the highest peak in clean spectra as the trial ones, we computed the best least-squares fits of sinusoids using the main program of PERIOD (Breger 1990) which can examine up to seven trial frequencies simultaneously without prewhitening the data.

The clean spectra for V, B, and U data shows the same distinct feature: the power is highly concentrated in a narrow range near 0.5 c/d (cycles/day). These clean spectra in the 0 –2 c/d range are displayed in Figure 1. Computations by using PERIOD have shown that frequencies of the best 7 frequency fits to different data only coincide for the two strongest ones: 0.40 c/d in all V, B, and U and 0.60 c/d in V and B. Using the mean frequencies and phases derived from V and B as fixed parameters, we determined the final fits to individual datasets as listed in Table 1, where in parentheses the formal errors are given in units of the last figure of significance. In Figure 2 phase diagrams are plotted for data phased with the primary and then phased with the secondary frequency 0.462 c/d (top) and the same data but prewhitened with the primary and then phased with the secondary frequency 0.603 c/d (bottom). Obviously, the two frequencies are coherent over many cycles during the campaign. The clean spectra and the multi frequency fits to the $uvby$ data exhibit the same two strongest frequencies. Since Since the UBV and $uvby$ observations partly overlap in time, the minor difference between the two determinations may be caused by systematic errors and we take them as resulting from the same physical process.

The frequencies near 0.46 and 0.60 c/d derived in this study are in good

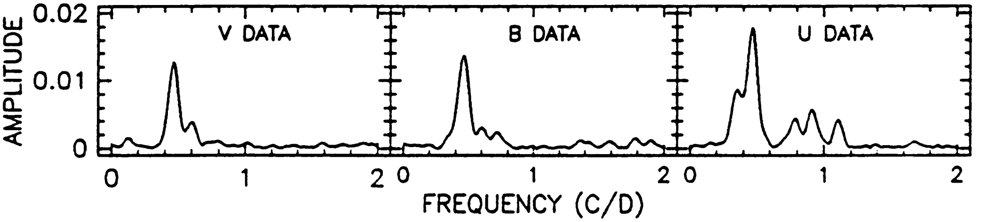

Fig. 1. Clean spectra for light variations of 53 Persei in 1991 January

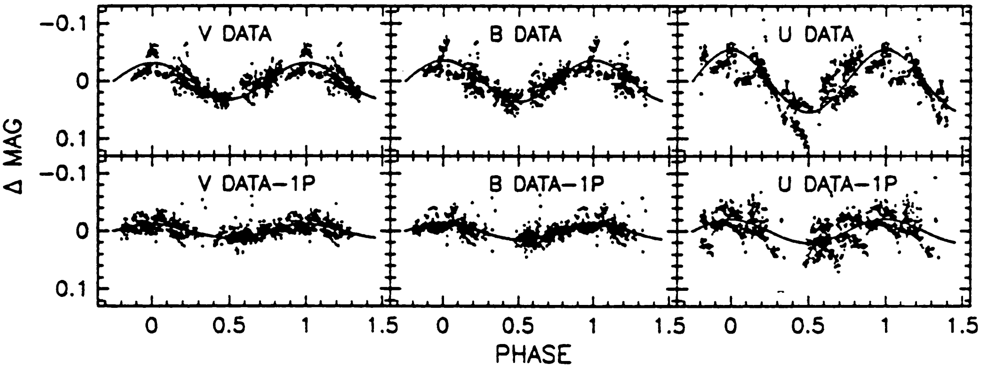

Fig. 2. Phase diagrams for light variations of 53 Persei in 1991 January

agreement with 0.464 and 0.595 c/d found by Smith and coworkers (Smith & McCall 1978; Buta & Smith 1979; Smith and Buta 1979; Smith et al. 1984) from observations obtained in 1977–1983. The difference between them is comparable to the errors. We believe that the pair of frequencies derived from observations more than ten years apart represent the same phenomenon. Therefore, we have confirmed, mainly on the more reliable basis of multi-longitude observations, the stable multiperiodicity in 53 Per and the stability duration is extended from 5.5 years (Smith et al. 1984) to about 13 years. This pivotal result strongly supports the viewpoint that NRP is present in this archetypical star.

TABLE I
Final 2-frequency fits for the UBV campaign datasets

Data	Amplitude (mag)	Zero-point (mag)	Residuals (mag)	Fixed Parameters (see text)
V	0.0317(6)	4.8447(16)	0.0101	Mean frequency (c/d):
	0.0122(21)			$f_1 = 0.4620(8)$, $f_2 = 0.6030(27)$
B	0.0363(22)	4.8074(7)	0.0108	Mean phases(cycles):
	0.0145(11)			$\phi_1 = 0.233(8)$, $\phi_2 = 0.665(28)$
U	0.0544(14)	4.2376(73)	0.0216	Mean Periods (days):
	0.0205(20)			$P_1 = 2.164(4)$, $P_2 = 1.658(7)$
$B - V$	0.0046(29)	−0.0374(23)	0.0068	Epochs of Light Maxima:
	0.0021(33)			T_{1max} = HJD 2448261.724(19)
$U - B$	0.0179(36)	−0.5697(80)	0.0209	T_{2max} = HJD 2448261.501(53)
	0.0058(31)			

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