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Pulsations in 66 Oph: Multiperiodicity in He I 6678

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Abstract. 66 Oph has shown recurrent short-lived outbursts nicely detected from ground-based and space (Hipparcos) photometry.
Spectroscopic observations of He I 6678 and Hα lines were performed in June 1997 and June 1998. Search for short-term periodicities was done in He I 6678 line profiles as in equivalent width EW, radial velocity of the line centroid, and V and R components. At least two frequencies were present: $\nu = 4.0$ c/d and $\nu = 2.2$ c/d. The phase distribution of these frequencies over the line profile corresponds in the *nrp* frame to g-modes with $\ell \sim 3 - 4$ and $\ell = 2$ respectively.

1. Introduction

The Be star 66 Oph (HD164284, B2V, $V \sin i = 280$ km/s) is known to exhibit a strong variability in Hα intensity. Following Hubert-Delplace and Hubert (1979) this star, regularly observed from 1953 to 1976, displayed a minimum in the strength of emission around 1955. Since then, the strength of emission has gradually increased. According to many data found in the literature, Hα intensity reached a maximum between 1987 and 1993. During this last period, the star was regularly observed at Kitt Peak by Peters who reported a strong variability in the strength of the line.
Ground-based and space (Hipparcos) photometric surveys displayed also a strong light variability with recurrent short-lived outbursts (Percy et al. 1988, 1992, 1997; Pavlovski et al. 1997, Hubert and Floquet 1998) between 1989 and 1993, superimposed on a monotonic decrease of brightness. The time spans between outbursts are 400-500 days and the amplitudes of these outbursts are ≥ 0.15 mag.
From Figure 1, it seems that each maximum of Hα intensity is anti-correlated with visual brightness (Hp magnitude). This star is a very good candidate for a search of a possible connection between *nrp* and mass loss episodes.

2. Spectroscopic observations

66 Oph was observed at the Haute Provence Observatory in June 1997 and June 1998 as Hα has begun the long-term decline. The He I 6678 and Hα lines were monitored with a spectral resolution of 22000. Search for periodicities was performed on 1998's data of He I line by using TF + Clean algorithm and Least

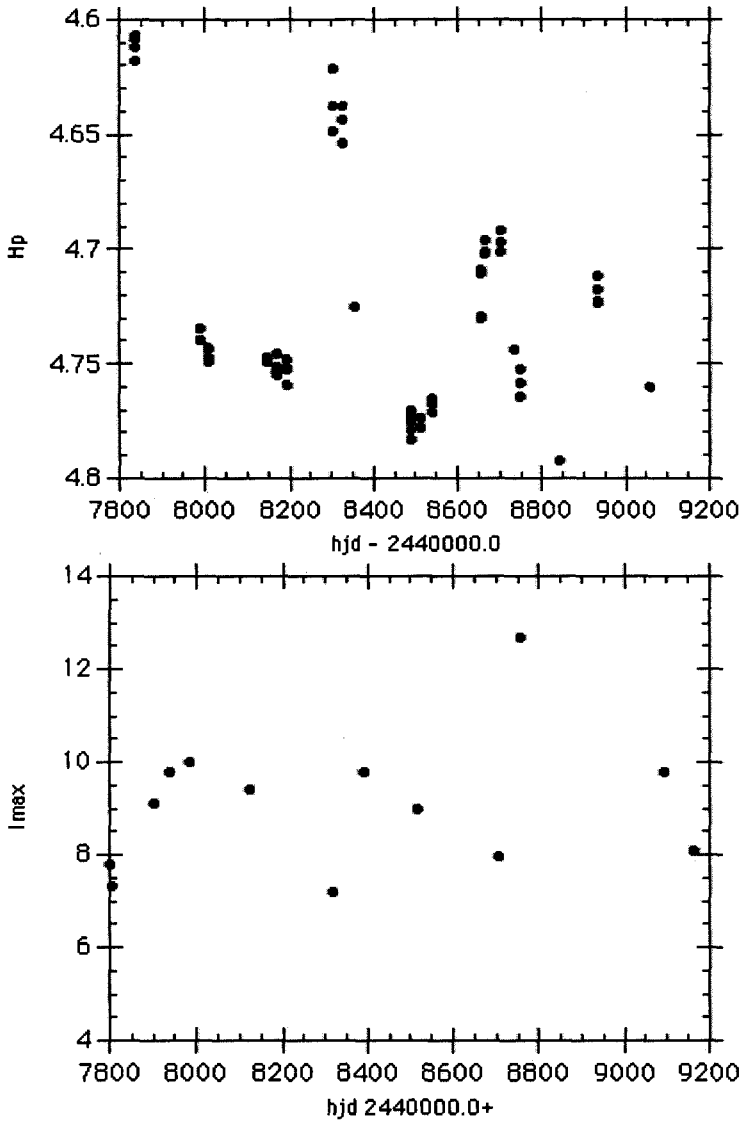

Figure 1. Correlation between the maximum of intensity of Hα and the outbursts observed in photometry. Upper panel: Hipparcos photometry; Lower panel: Hα intensity

Squares method. These methods were applied to line profiles, equivalent width EW, radial velocity of the line centroid RV, intensity of V and R outer emission components and V/R ratio.
The intensities of V and R, EW and V/R of the Hα emission line were also measured.

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3. Hα line

The Hα line of 66 Oph is in strong emission with two well separated peaks, this profile being typical of a star seen at an intermediate angle of view. Our observations took place on a decreasing branch of the Hα intensity curve, after the maximum observed between 1988 and 1993, and the decrease of intensity between 1997 and 1998 is more conspicuous in the blue part of the line. Measurements of EW, I(V) and I(R) and V/R ratio are given in Table 1.

Table 1. Hα line of 66 Oph

Date	EW (Å)	I(V)	I(R)	V/R
June 1997	−40.6	6.66	6.54	1.018
June 1998	−35.1	5.94	6.09	0.975

4. He I line

The He I 6678 line presents a highly variable photospheric profile disturbed in its outer wings by V and R also variable emission components. As for Hα, we

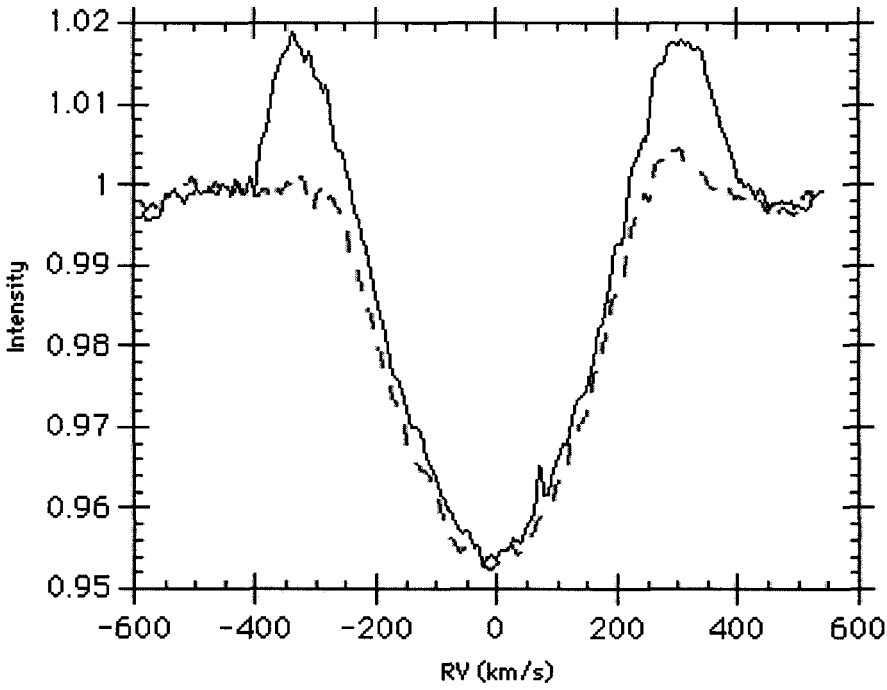

Figure 2. Mean He I 6678 profiles in 1997 (full line) and 1998 (dashed line)

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observe a decrease in 1998 of the intensity of V and R. In 1997 these latter were always present and strong, but in 1998 the V component was often weak and sometimes undetectable (Figure 2). The V/R ratio oscillates around the value 1.001 in 1997 and 0.996 in 1998 with the same frequency $\nu = 2.19$ c/d.
The equivalent width and the radial velocity of the centroid were measured on the observed absorption part of the line profile. The results of time series analysis of parameters and line profiles are given in Table 2. Two frequencies are mainly present: $\nu = 2.20$ c/d and $\nu = 4.05$ c/d. The 2.20 c/d frequency is clearly dominant in RV, V, R and V/R ratio, as the 4.05 c/d frequency is dominant in the photospheric part of the profile. From the associated phase velocities across the line profile, and in the frame of non-radial pulsations, these frequencies correspond to $\ell = 2$ and $\ell = 3 - 4$ g-modes respectively.
The first harmonic of the 2.20 c/d frequency is found in EW, I(R) and V/R ratio.
This star is reported as variable in radial velocity in the literature. It is consistent with the asymmetry changes of the photospheric profile and the subsequent displacement of its core with a peak to peak amplitude of 25-30 km/s. This variability is dominated by the frequency $f = 4.04$ c/d.

Table 2. Short-term variability in the He I 6678 line of 66 Oph. Frequencies in c/d, obtained by Least Squares method, are given in order of decreasing power. For He I line profiles only 1998 data have been considered. All the other quantities include 1997 and 1998 data.

Profiles	EW	$RV_{centroid}$	I(V)	I(R)	V/R
4.05	4.45	2.21	2.17	2.21	2.19
2.22		4.10		4.35	1.03
					4.36

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