

A Spectroscopic Search for Non-Radial Pulsations in Early B-Type Stars

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It is known that early-B type main-sequence stars can be unstable against pulsations induced by the κ mechanism. Traditionally, radial and low-degree non-radial β Cephei-like pulsations have been detected photometrically; nowadays radial, low-degree and intermediate-degree pulsations can be detected spectroscopically through line-profile variations (LPVs). Whereas most of the brightest early-B type stars have been photometrically monitored for variability (72 of the 541 O9.5-B3 III-V stars in the BSC are classified as β Cephei stars), a systematic LPV survey to look for pulsational behaviour was lacking. Here we present some preliminary results of the southern part of our spectroscopic survey of early-B type stars. We have made a high spectral resolution survey of the Si III λ 4552, 4567, 4574 Å triplet in early-B type stars in order to look for LPVs due to non-radial pulsation (NRP). Our sample consists of 82 southern O9.5-B3 stars with spectral classes III-V, taken from the BSC; 27% of all O9.5-B2.5 III-V stars in the BSC were sampled. This sample is not fully representative for all nearby early-B stars, because we concentrated on stars with high rotational velocities, because many of the stars are members of the Sco-Cen associations, and because we focused on the β Cephei stars in the BSC. As much as 40% of the β Cephei stars in the BSC with $v \sin i \geq 25 \text{ km s}^{-1}$ were sampled. The observations were carried out with the ESO CAT telescope at resolution $R \sim 65000$. Our targets were observed during 6 runs in September 1995 – June 1998. Some stars were observed many times, but most targets were observed only once or twice.

We have concentrated on detecting LPVs in the form of Doppler-mapped quasi absorption and emission bumps that are typical for NRP in stars with rotationally broadened lines. We used the presence of such bumps in the Si lines as an indicator of the likely presence of NRP. For stars with only one spectrum we checked for the clear presence of bumps in the available lines of the Si triplet. For stars with more than one spectrum we checked whether the LPVs caused by the moving bumps resemble that of NRP. Line shifts and broadenings were taken as indicators for low-degree pulsations ($\ell \lesssim 2$). For stars in which we detected LPV, follow-up observations are needed to confirm the presence of NRP.

Table 1. Targets with detected LPV. Values of $v \sin i$ indicated with * were estimated from our spectra, others are from the BSC. Last column: 'r' rectification problems; 'b' possible mis-identification due to binarity; '2' double-lined binary; 'n' S/N too low to be conclusive.

object	$v \sin i$	N	bumps	degree		object	$v \sin i$	N	bumps	degree	
α Lup	24	2		lo	b	β Cen	139	4	yes	hi	2
ν Eri	25	3		lo		ψ^2 Ori	141	1	yes	hi	2
κ Cen	28	7	yes	hi	b	ω^1 Sco	142	89	yes	hi	
V357 Car	30	9		lo	b	V372 Car	147	25	yes	hi	
QU Pup	~30*	2		lo		α Mus	147	14	yes	hi	
θ Oph	35	4		lo		7 Mon	152	2	suspect	hi	b,n
α Tel	35	19	yes	hi		ρ Sco	156	2	yes	hi	
α Pav	39	2		lo	b,n	α Vir	159	3	yes	hi	
μ^1 Cru	48	1	suspect	hi	n	ϵ Cen	159	539	yes	hi	
EY CMa	49	2	yes	hi/lo		HR 3089	160	1	suspect	hi	n
QS Pup	~50*	2	suspect	hi	n	HR 3359	163	1	suspect	hi	
σ Sco	53	5		lo		λ Sco	163	26	yes	hi	
μ^2 Sco	57	1	yes	hi	b	VV Ori	168	1	suspect	hi	b
ζ CMa	63	3	suspect	hi/lo	b,n	HR 3294	169	46	yes	hi	
HR 7029	65	4	yes	hi/lo	b	HR 6960	172	3	yes	hi	
HR 3358	66	36	yes	hi		HR 3293	178	13	yes	hi	
ν Sco	73	10	yes	hi	2	HR 3453	181	4	suspect	hi	n,b,2
HR 6143	90	6	yes	hi		δ Sco	181	121	yes	hi	
ν Cen	91	98	yes	hi		QZ Pup	187	7	suspect	hi	n
γ Col	96	1	suspect	hi		δ Cru	194	18	yes	hi	
π Sco	100	1	suspect	hi	b,2	HR 3819	207	19	yes	hi	2
V2052 Oph	120	7		lo		OS Pup	213	2	yes	hi	
ν^1 Cen	122	3	suspect	hi	n	δ Lup	221	2	yes	hi	
ϕ Cen	126	6	yes	hi		σ Cen	245	4	suspect	hi	r
β Lup	127	85	yes	hi		HX Vel	285	1	suspect	hi	r,b,n
β^1 Sco	130	2	suspect	hi	n	HR 3476	288	1	suspect	hi	r,b,n
κ Sco	131	18	yes	hi		23 Ori	295	1	suspect	hi	r,b,n
ϵ Lup	133	3	yes	hi	2						

The Doppler-mapped NRP bumps are most apparent for pulsating stars with rotation velocities $50 < v \sin i < 250 \text{ km s}^{-1}$. For lower rotation velocities the broadening is not high enough to be able to resolve the stellar disc in velocity space; for higher rotation velocities the lines of the Si III triplet are so shallow and broad that the detection of bumps in just one or two spectra is very difficult because of S/N limitations and errors in continuum normalization. In Be stars with strong disc emission the region of the Si III triplet is polluted by Fe II emission lines, hampering easy detection of NRP in the Si lines.

We find that 40 out of the 57 stars with $50 < v \sin i < 250 \text{ km s}^{-1}$ in our sample show evidence for LPVs. For stars that were not previously known to have a β Cep/NRP nature, and that have $50 < v \sin i < 250 \text{ km s}^{-1}$, 26 out of 37 show NRP-like bumps. This most probably indicates that many early-B type stars are pulsationally excited.