INTEGRAL OMC analysis of the symbiotic star RS Oph

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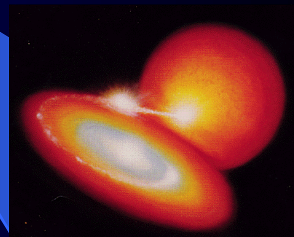

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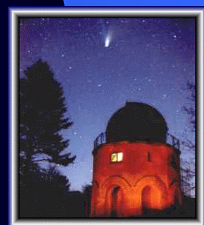


SYMBIOTIC STARS

- Heterogeneous group – often late-type giant transferring mass onto a compact object (a WD or a neutron star) via a strong stellar wind or in some cases via Roche lobe overflow (more than 100 symbiotics known)

- Most symbiotics are the long-period causins of CVs and X-ray binaries (e.g. Mikolajewska & Kenyon 1992)

- Dramatic variability on a large range of time scales (from seconds to years and decades)

Classification of symbiotics by Murset et al. (1996):
group α: supersoft X-ray spectra (hot white dwarfs?)
group β: harder X-ray spectra (colliding winds?)
group γ: relatively hard X-ray sources (neutron star instead of a WD?)

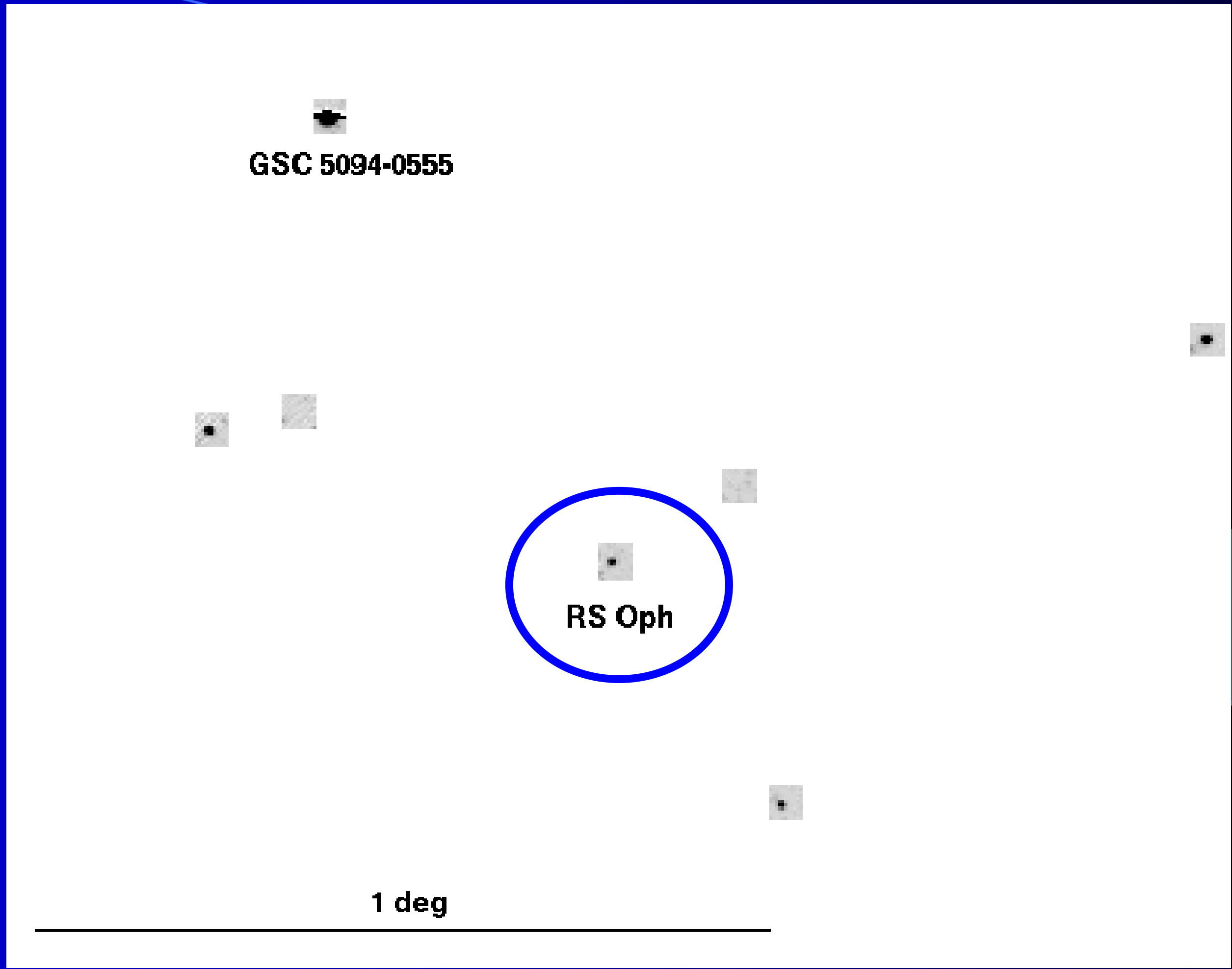
INTEGRAL – suitable for:
(a) detection of symbiotics with the hardest X-ray spectra
(b) simultaneous obs. in the optical and hard X-ray regions
(c) long-term obs. with OMC – including a search for rapid variations in obs. series during sci. window

RS Oph

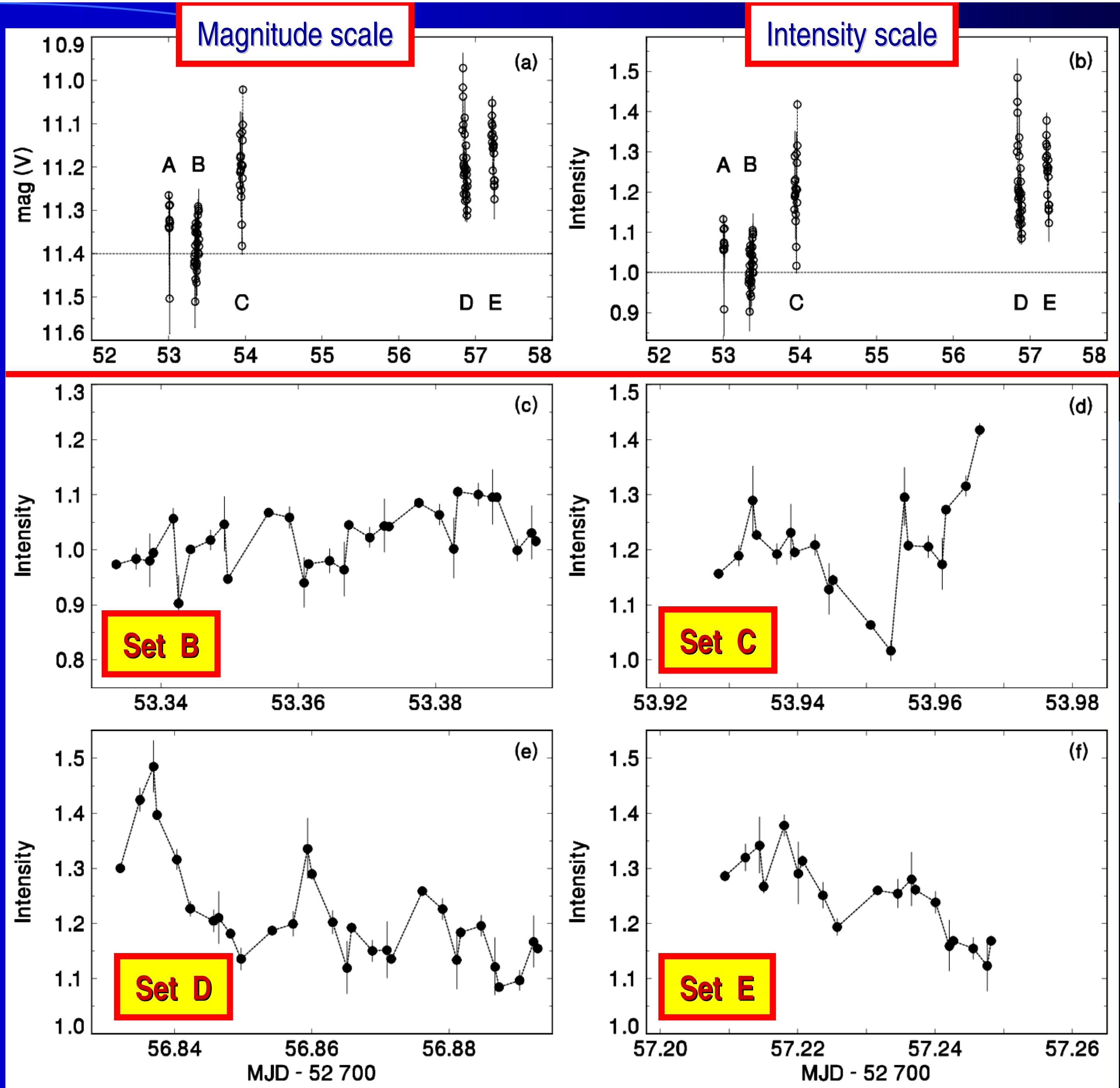
- relatively bright symbiotic star
- orbital period P_{orb}=460 days
- inclination angle 30° – 40°
- giant component underfilling its lobe (Dobrzycka & Kenyon 1994)
- white dwarf (WD) – recurrent nova (five observed explosions) (e.g. Warner 1995)

- Quiescent brightness – fluctuations (months and years) 11 – 12 mag(V), sometimes 10 mag(V) (e.g. Dobrzycka & Kenyon 1994, Oppenheimer and Mattei 1996)

- Rapid optical variations – time scale of tens of minutes, similar to those often seen in short-period CVs (e.g. Walker 1977, Dobrzycka et al. 1996)



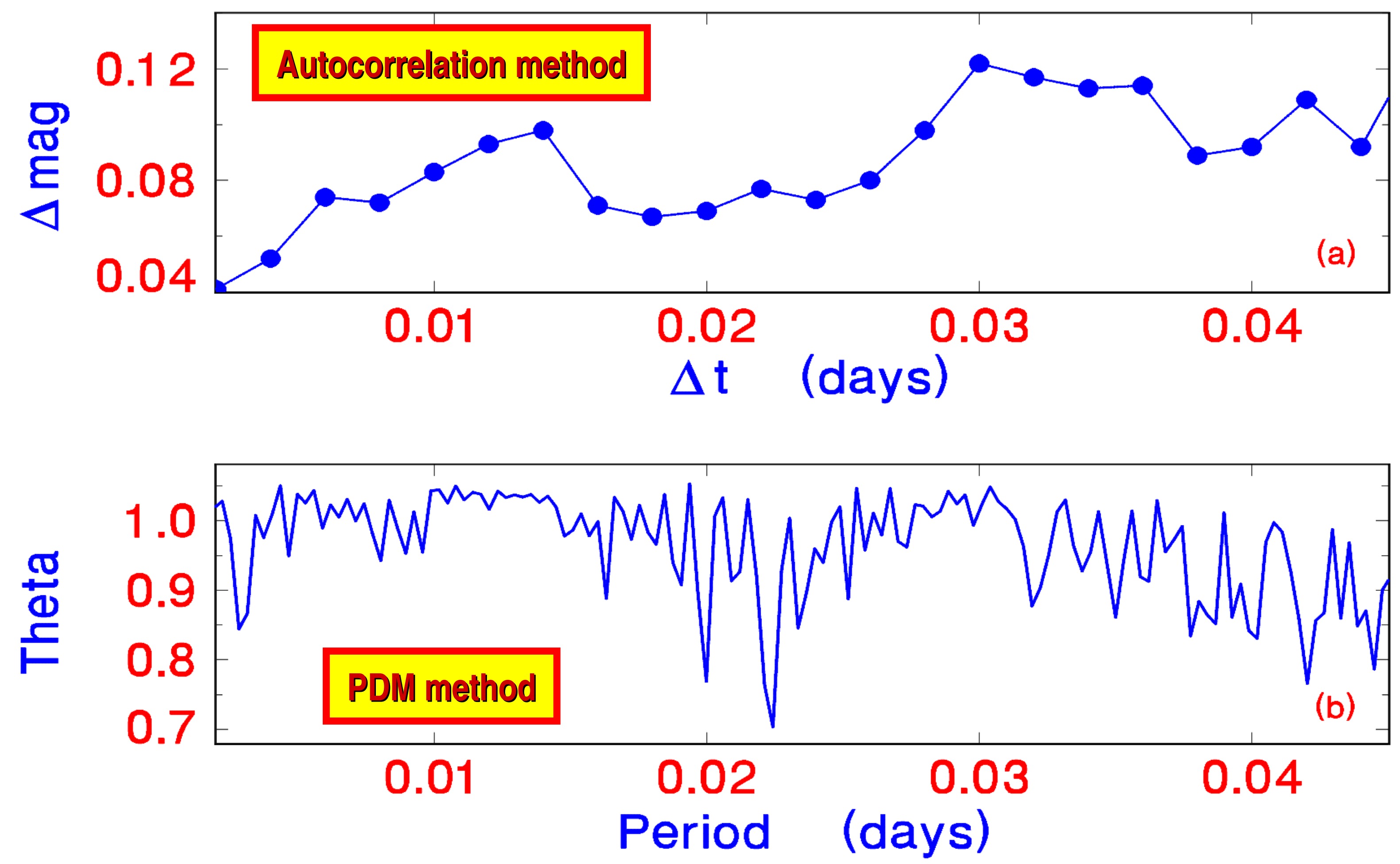
Field of the cataclysmic/symbiotic variable RS Oph on the OMC frame (*V*-filter), taken on MJD 52753.3685, exp. 100 sec.



RS Oph

V **band light curves from OMC**

Strong rapid variability with a prominent flickering



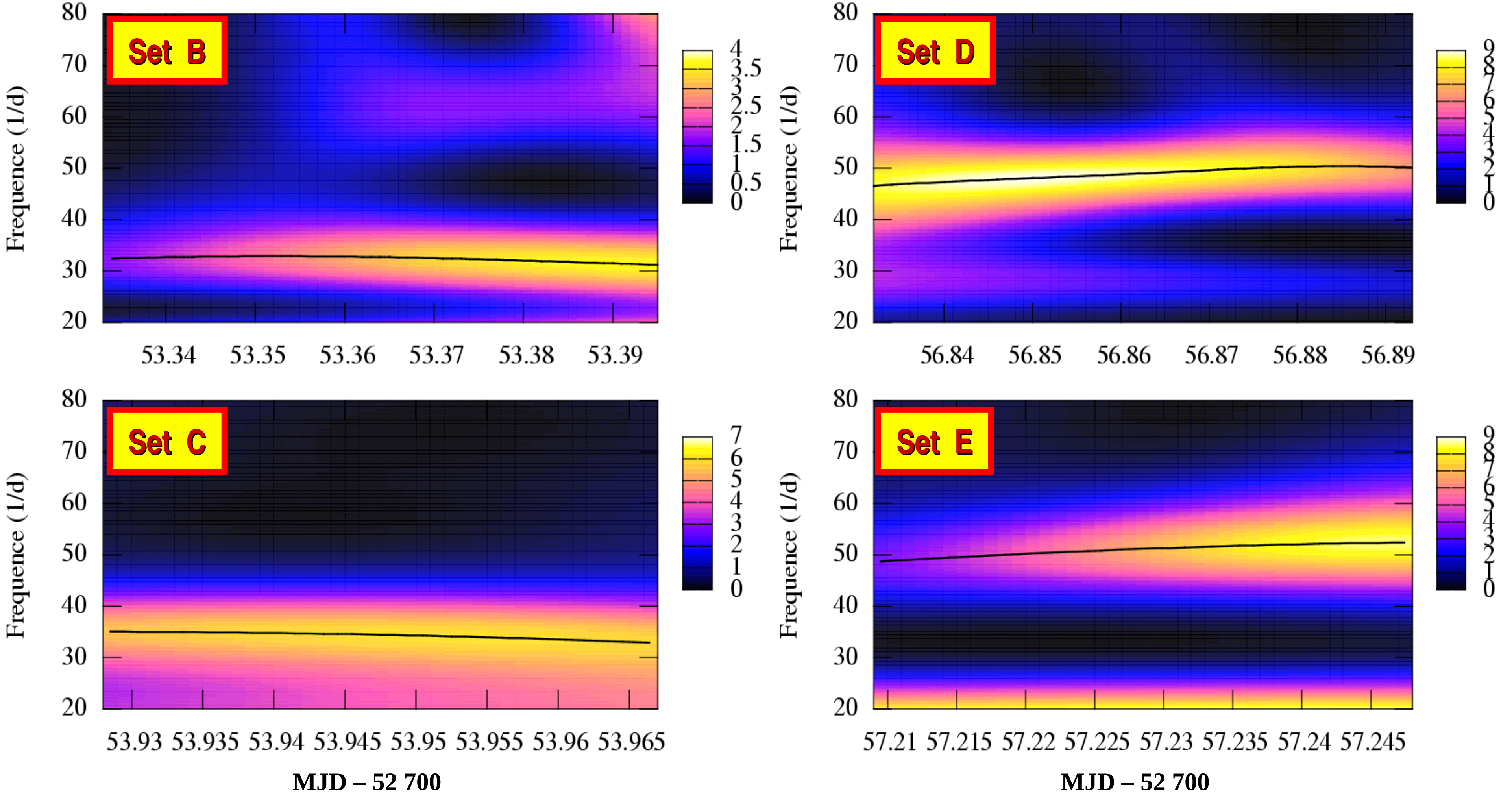
Periodograms of sets C+D+E of RS Oph.

(a) autocorrelation (method of Percy et al. 1981)

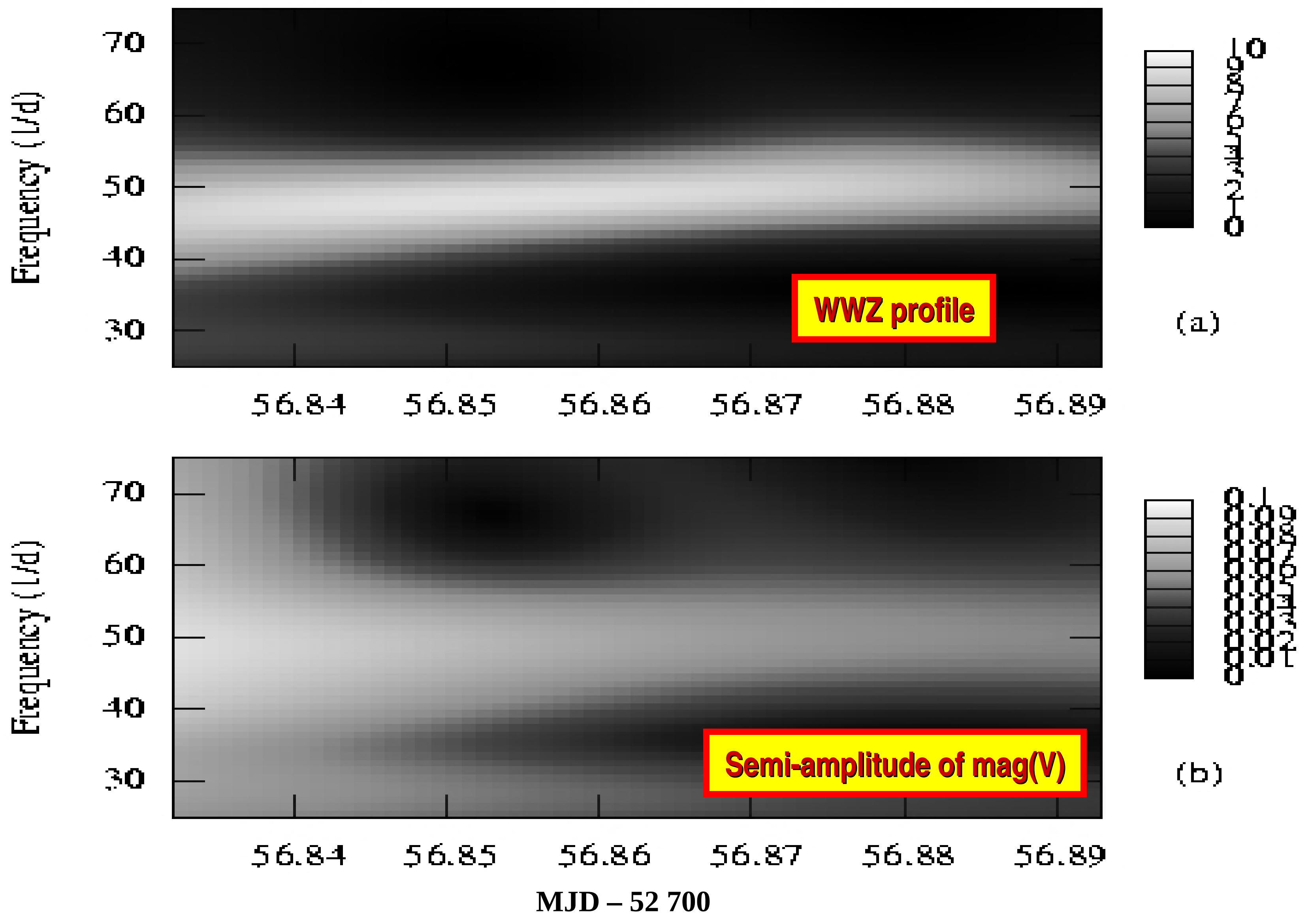
(b) PDM (phase dispersion minimization) method (Stellingwerf 1978, Widjaja 1996)

Both methods reveal a cycle-length near 0.02 days.

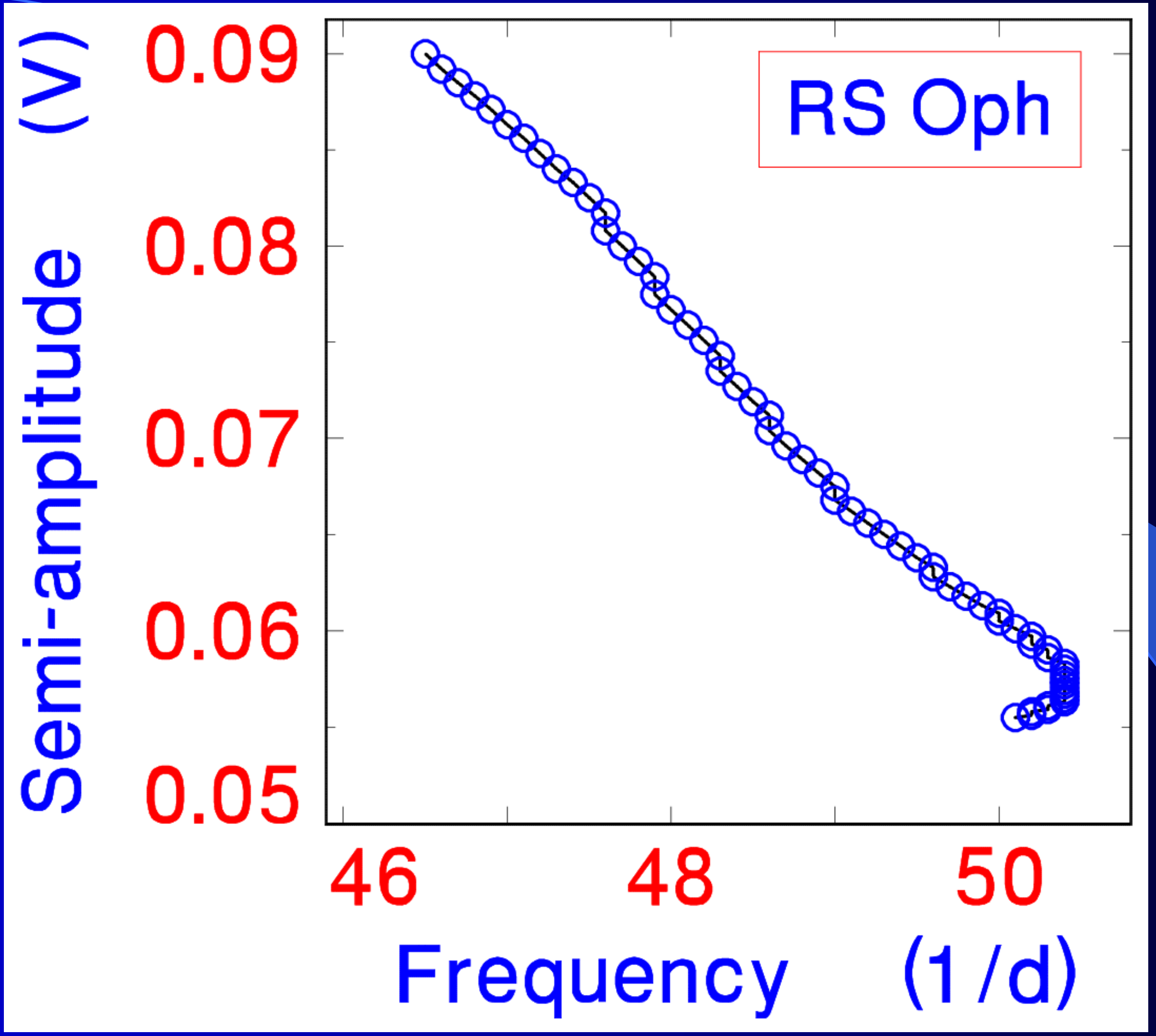
This cycle is present also in the individual sets.



Weighted wavelet Z-transform of the individual sets of RS Oph. WWZ indicates whether or not there is a periodic fluctuation at a given time at a given frequency (method of Foster 1996). Dotted curves – maximum of WWZ. Range of ordinate identical for all panels. Length of abscissa for each set – length of science window of *INTEGRAL*.



Weighted wavelet Z-transform of set D of RS Oph. (a) Profile of WWZ, indicating whether or not there is a periodic fluctuation; (b) Profile of weighted wavelet amplitude, giving the semi-amplitude of variations (method of Foster 1996).



Relation between the frequency of the maximum WWZ and semi-amplitude of the flickering in set D

Results of OMC observations of RS Oph

- Observations in orb. phases 0.9848 – 0.9935 (ephemeris: Dobrzycka & Kenyon 1994) – at primary eclipse if RS Oph were eclipsing
  - still important phase – e.g. wind flow from giant toward WD can still influence our view into the vicinity of the WD

- RS Oph observed with OMC at various levels of brightness (lower value ~11.45 mag(*V*)) – the lowest one at which flickering of this object was analyzed

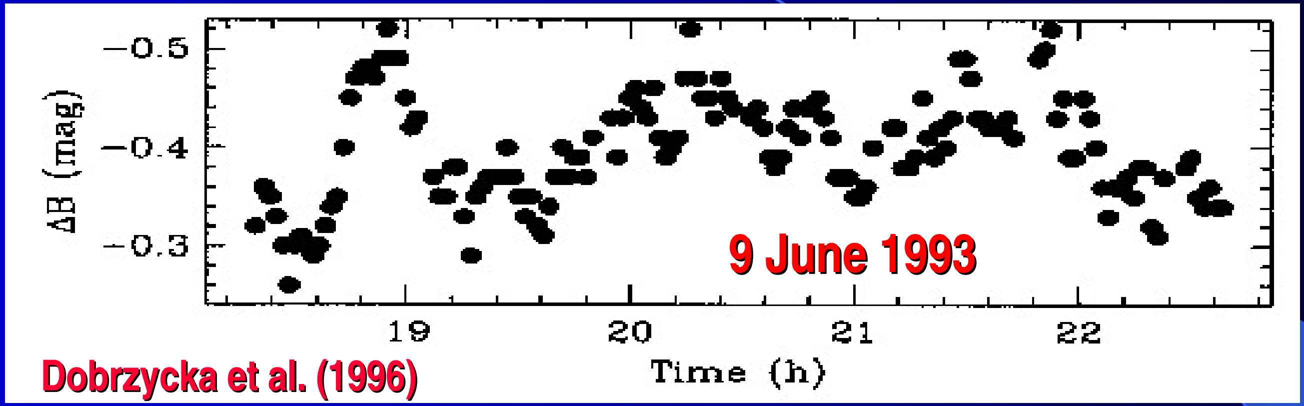
- Rapid variations of brightness in sets BCDE:
  - Largest peak-to-peak amplitudes ~0.3 mag(*V*) in sets C and D
  - Generally: Amplitude of flickering tends to increase with increasing mean level of intensity – origin of both flickering and "constant" optical luminosity from the same source

- WWZ method – detection of typical frequency of flickering for each set
  - typical frequency 30 – 50 cycles/day (i.e. period 48 – 29 min)
  - frequency tends to vary with varying mean intensity of sets !
    - set B (lower mean intensity than sets CDE): flickering with lower freq and smaller amplitude than in CDE
    - set D: variations of frequency also in the course of the set

- Complicated relation between amplitude of flare in flickering and its duration inside a given science window:
  - Set D – amplitude decreases with decrease of cycle-length (and hence duration of flare)

- Short time scale of flickering – most probable location in close vicinity of the WD (supported also by rapid variations of He II 4686 emission (Sokoloski 2002))

- All this contradicts the origin of flickering from rotation of magnetized white dwarf – typical periods of flickering found here are quite discordant with period of 81+/-2 min (Dobrzycka et al. 1996)



- Level of "constant" intensity plays a role in the current properties of of flickering in RS Oph.

- Relation between amplitude of rapid and long-term variations in RS Oph is in the same sense as in CH Cyg (Sokoloski 2002, Sokoloski & Kenyon 2003) and T CrB (Anupama & Mikolajewska 1999)

- Our observations in agreement with finding of Bruch (1992) for CVs – luminosity of flickering and "constant" source in CVs are correlated

Acknowledgements:

This study was supported by the project ESA PRODEX INTEGRAL 14527. The WWZ code by G. Foster is available at URL: www.aavso.org/data/software/wwz.shtml.