GP18

Pulsation of the δ Scuti Multiple System DG Leo*

**P. Lampens[1], Y. Frémat[1], R. Garrido[2], J.H. Peña[3], L.Parrao[3], P. Van Cauteren[4],
J. Cuypers[1], P. De Cat[1], H. Hensberge[1], T. Arentoft[5], P. Mathias[6] and M. Hobart[7]**

[1] Royal Observatory of Belgium, ringlaan 3, B-1180 Brussel, Belgium [2] Instituto de Astrofísica de Andalucía Camino Bajo de Huetor 24, 18008 Granada, España
[3] Instituto de Astronomía, UNAM Apartado Postal 70-264 México 04510, D.F. [4] Beersel Hills Observatory, Laarheidestraat 166, B-1650 Beersel, Belgium
[5] Department of Physics and Astronomy, Aarhus University, DK-8000 Aarhus C., Denmark
[6] Observatoire de la Côte d'Azur, Département Fresnel, UMR 6528, F-06304 Nice Cedex 4, France
[7] Facultad de Fisica, Universidad Veracruzana, A.Postal 270, Xalapa, Veracruz, Mexico

$\star$ **Based on observations obtained at San Pedro Martír, Sierra Nevada, Beersel Hills Observatories and the Observatoire de Haute Provence.**

Contact: patricia.lampens@oma.be & yves.fremat@oma.be

Abstract

DG Leo is a spectroscopic triple system showing δ Scuti type photometric and spectroscopic variations. The 3 components have nearly equal mass but a different chemical composition in the outer layers and all three are potential pulsators. Frequency analyses of the photometric data were carried out using various methods. These global results together with considerations coming from the spectroscopic analysis allow us to present a discussion of the behaviour of each component with respect to pulsation.

1. Introduction

A bonus to the study of pulsating stars in binary and multiple systems is that one can exploit the dynamical information to obtain independent information on the physical properties in order to gather more constraints on the pulsational models. Multi-year photometry with a good phase coverage of the beat periods of the oscillations permits, on one hand, to perform an accurate frequency analysis. A careful spectroscopic analysis, on the other hand, may provide information on the mass and luminosity ratios, the effective temperature, the metallicity and the superficial gravity of each component provided the spectrum is composite. By furthermore studying and comparing the pulsational content of the components which originate from the same protostellar environment, one may realistically hope to obtain clues to better understand the pulsation physics since a difference in pulsational behaviour between each can only be attributed to a limited number of (differing) stellar parameters or physical processes. In a review of δ Scuti stars in known double or multiple stars, Lampens & Boffin (2000) discussed several potentially interesting objects, one of which was DG Leo which appears to be a triple system with all three components potential pulsators. Fundamental parameters of the components are discussed in **poster FP12** while we propose to discuss their variation patterns by confronting photometric to spectroscopic results.

2. Photometry

Photoelectric photometry campaigns were carried out during the recent years 2002, 2003 and 2004. The main bulk of the data was collected during a few weeks at two good sites located at different longitudes and equipped with identical instrumentation and standard Strömgren filters: namely the observatories of San Pedro Martír (OAN), México, and Sierra Granada (OSN), Spain. Additional CCD differential measurements were obtained at Beersel Hills Observatory (BHO), Belgium, covering a period of several months in 2003. The analysis of these data (based on a total of 2514 measurements) shows that most of the photometric variability can be modelled by a composite sine wave with at least four frequencies, as illustrated and detailed in Fig. 1 (Lampens et al. 2004).

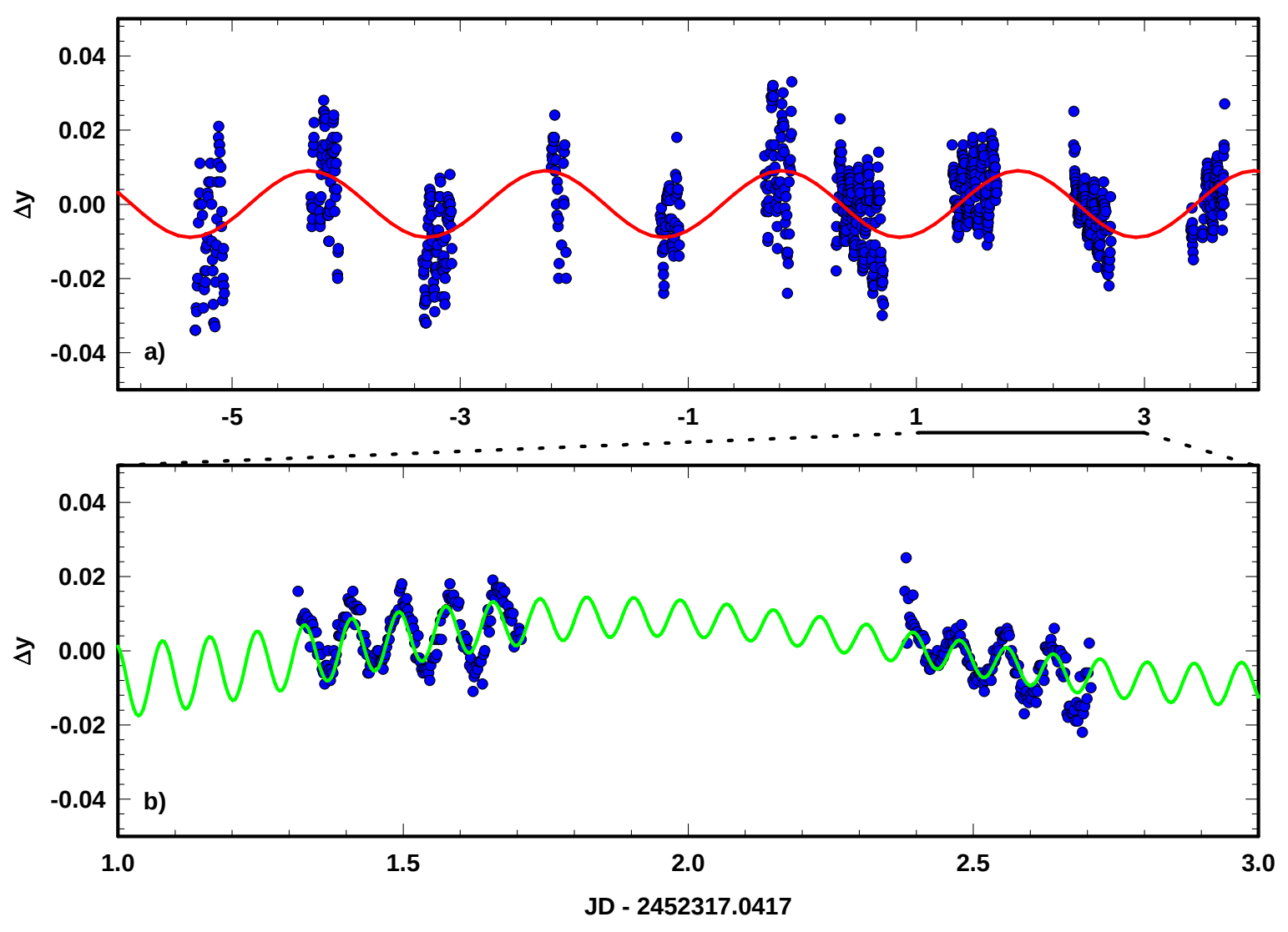

Fig. 1: a) In DG Leo's photometry the highest amplitude variation is related to the tidal deformation (ellipsoidal variation) of the close binary components. Its periodicity corresponds to one half of the 4.15 days orbital period of the close binary. In this figure, predictions (assuming a sinusoidal variation) for the ellipsoidal variations (red curve) are compared to the observations (blue dots). **b)** Three other frequencies having close periods of about 2 hours were found to be caused by pulsation of at least one of the components of the triple system. We compare the predictions from the combined solution (ellipsoidal variation+pulsation) of the frequency analysis (green line) to some light curves in the y colour band obtained during 2003 (blue dots).

3. Spectroscopy

The acquisition of the spectroscopic data is described in **poster FP12**. The spectral disentangling that was carried out using the KOREL computer code (Hadrava 1995) allowed us to determine the radial velocity of the components even at phases where their contributions cannot be spectroscopically resolved by traditional techniques. Significant short-term ($\sim$ few hours) variations are detected for component B only (see Fig. 2).

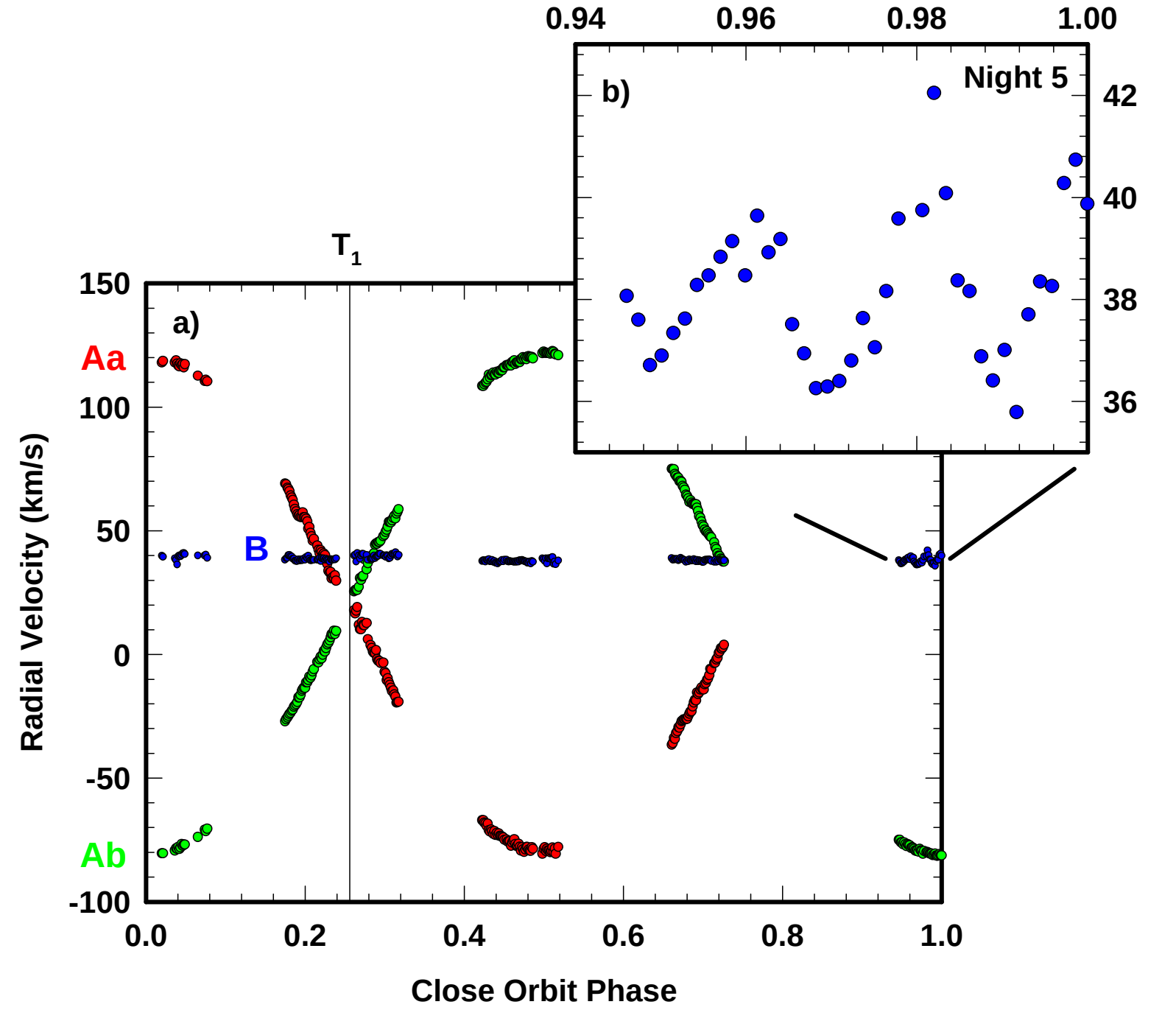

Fig. 2: Spectral disentangling of high resolution spectra (see **poster FP12**) also allows to obtain the instantaneous radial velocity of the components. In **panel a**, T_1 stands for the epoch at which both A components have the same radial velocity. In **panel b**, radial velocity variations due to pulsation are clearly seen in the observations made during Night 5 (see also **panel a**).

After each exposure, the INTERTACOS pipeline (Baranne et al. 1996) was used to reduce the data and further provided us with a cross correlation function (CCF) computed using a F0 V line-template. These CCFs can be seen as the mean profile of about 2000 lines taken over the whole spectral domain covered by the ELODIE spectrograph. Strong variations of the cross correlation peak corresponding to DG Leo B were detected and are discussed in Fig. 3.

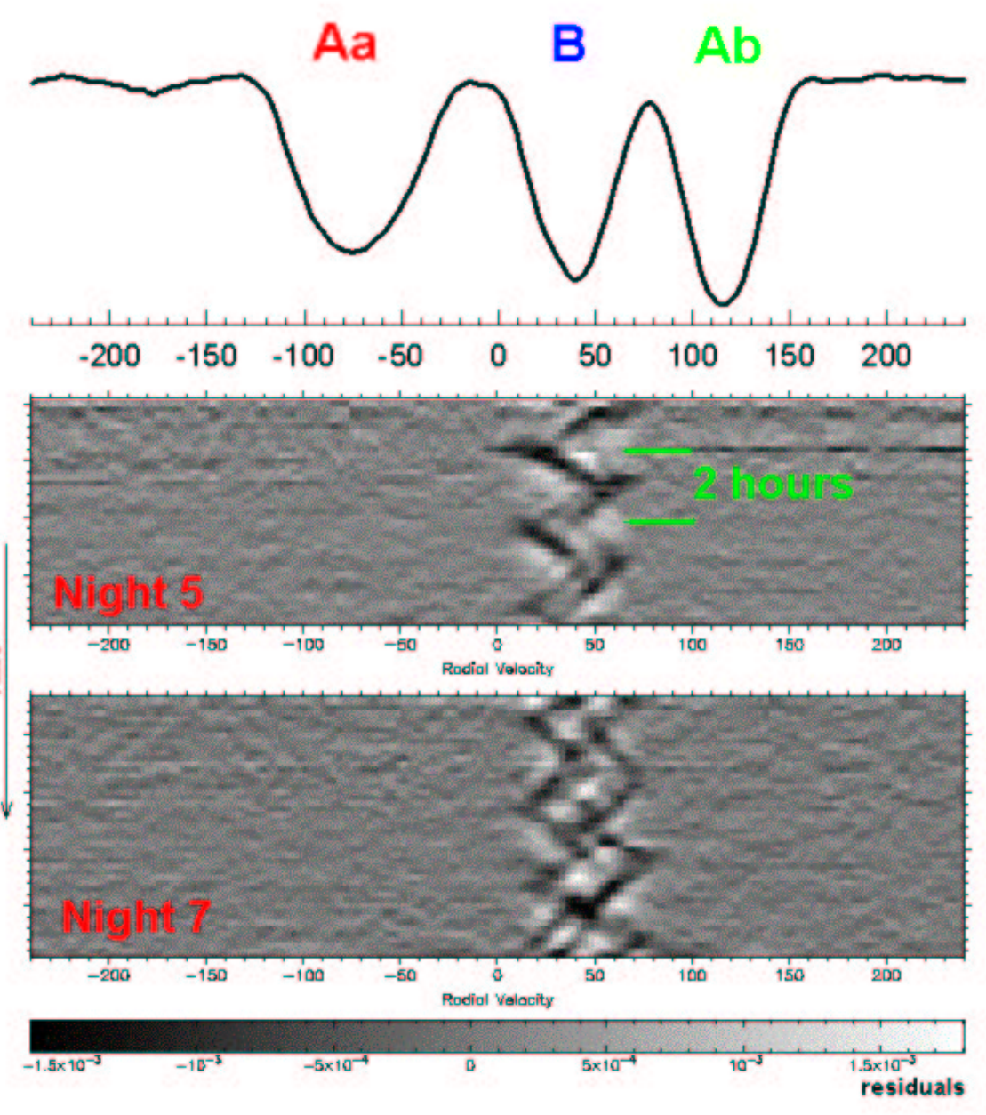

Fig. 3: The residuals of the instantaneous cross correlation functions (upper panel, where each peak represents the contribution of one component) show that the spectroscopic variations are restricted to component B as they are only centered on its correlation peak. Their period is of the order of 2 hours. Line profile variations (LPVs) are observed every night but their pattern changes from night to night. During Night 5 LPVs are mainly affecting the apparent radial velocity (see also Fig. 2) while in Night 7 LPVs are mostly appearing as bumps moving through the line. These differences are clear evidence for multiperiodic pulsation.

4. Spectroscopy & Photometry

The frequency solution obtained from the photometric data (w/o considering the ellipsoidal variation, i.e. F1) (see Fig. 1) was used to predict the light curves during those nights for which high-resolution spectra are available. In Fig. 4 we plotted the light curves as predicted from the 3-frequency solution (in red) as well as those predicted from the various 2-frequency combinations (in resp. green, blue, brown) together with the radial velocity variations of component B as derived from the spectral disentangling technique.

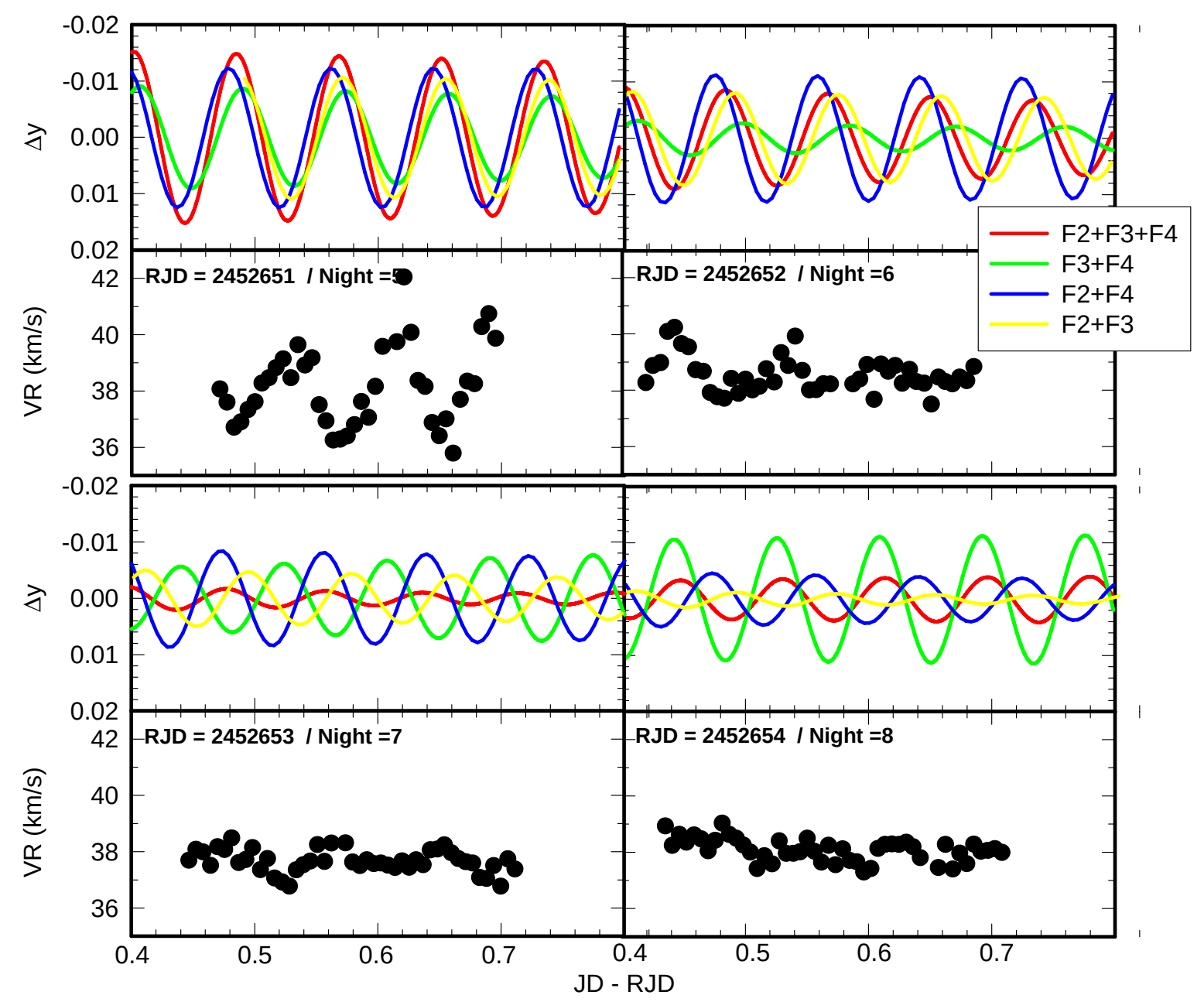

Fig. 4: At a predicted epoch of maximum beat amplitude, the amplitude in radial velocity is the highest observed (Night 5) while it decreases rapidly following a similar decrease in beat amplitude (Night 6) and becomes insignificant the next two nights (Nights 7 and 8), when the beat amplitude is minimum. We further note that the radial velocity variations during Night 5 are in anti-phase with the predicted light curve, a behaviour typical of δ Scuti variable in the presence of low degree modes. A preliminary conclusion is that at least two photometrically detected frequencies may be associated to component B. The next logical step will be to perform a frequency analysis of the spectroscopic data and directly compare its results to those derived from the photometry.

In **poster FP12** we showed that the projected rotation velocities of the components Aa and Ab are different while the orbit is definitely circular. Since we furthermore detect a significant phase lag between the epoch of minimum luminosity and the epoch of equal radial velocity between the components, we conclude that probably at least one of the components has not (yet) synchronized its rotation with the orbital motion (Zahn 1992).

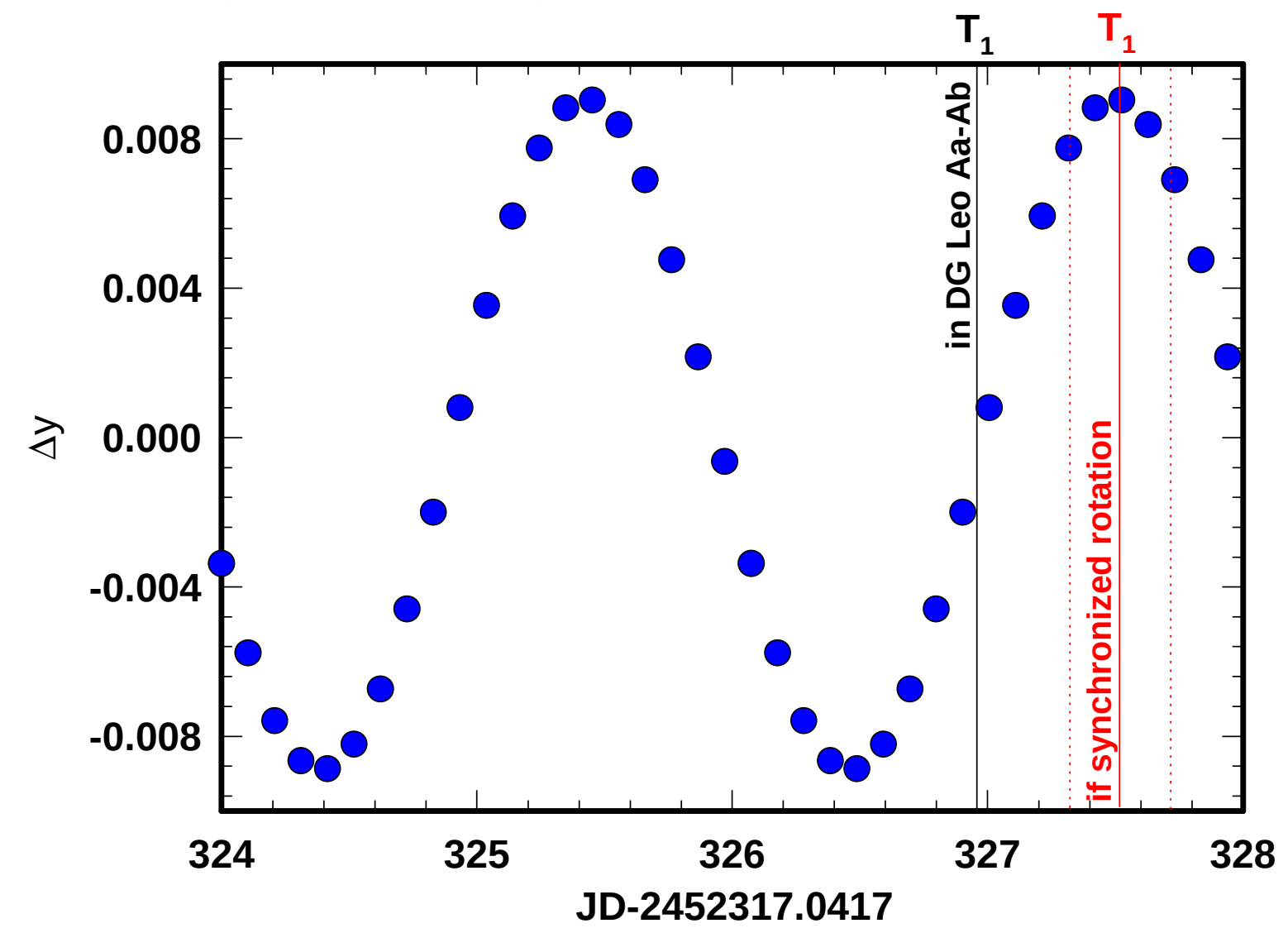

Fig. 5: When spin-orbit synchronization occurs, it is generally expected that T_1 corresponds to the epoch of maximum magnitude (ie: minimum luminosity). In this system there exists a significant phase lag between these two events showing that dynamical tides might occur and that the close pair is probably not synchronized(see also **poster FP12**).

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