A spectroscopic study of the cataclysmic variable V1040 Cen

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Abstract: We report the results of the first spectroscopic analysis of the dwarf nova V1040 Cen. We conclude that the orbital period of the system is 0.06049(10)d and derive an ephemeris. Using the radial velocities of the system we estimate K_1 = 73.9(4.5)km/s and γ = 40.4(3.4)km/s.
We put some constrains on the masses of the system, arriving to the conclusion that q must lie in the range 0.23 < q < 0.54 and that the inclination angle must be 71°< i < 74°

Average and trailed spectra

Most prominent lines are Hα 6562.760 Å and Hβ 4861.327 Å. Also we found some He I (6678.149 Å and 5875.618 Å) emission. We find double peaks in all the emission lines and S waves at trailed spectra. The double peaks are the first evidence of the accretion disc around the primary star, being confirmed by the presence of the S waves.

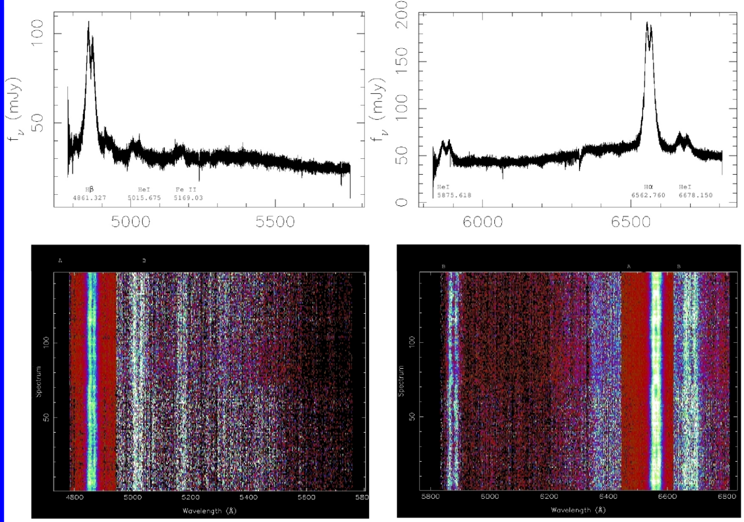

Fig1: Top-left, average spectrum is an average of 147 blue spectra. Top-right is an average of 147 red spectra. To produce this average we binned the spectra to the same wavelength scale (that of the first spectrum of every set).
Bottom, trails for 147 continuum-subtracted spectra. Time runs from bottom to top. Night 1 from spectra 1 to 71 and night 2 from spectra 72 to 147. Due to the difference of intensity between the lines, a common intensity scale is not usefull to plot a trailed spectra for all the lines. Thus, both figures (bottom left and right) are divided in two panels with different saturations each. Fig left, panel A is 13,6 % saturated, panel B is 1,8 % saturated. Fig right panel A is 75 % saturated and panel B is 2,7 % saturated. Left: panel A, trail for Hβ; panel B, trail for HeI and FeII. Right: panel A, trail for Hα; panel B, trail for HeI.

Orbital Period

By using Scargle's periodogram, after measuring radial velocities we estimate the orbital period as 0.06049(10)d. The uncertainty was calculated by the bootstrap method using 10000 bootstrap samples.

Doppler Tomography

Our tomograms displayed a ring that we identify as the accretion disc. The system presents an homogeneous disc. We detect two features which we identify as the bright spot and the secondary star. However this identification is uncertain and thus we have succesfully applied for a follow up infrared run on this system. Preliminarily the position of the would-be secondary star is usefull to estimate how off is the currently published value for the orbital periodAnother characteristic is the size of the disc in the image for Hα, which is strikingly smaller than in the other tomograms.

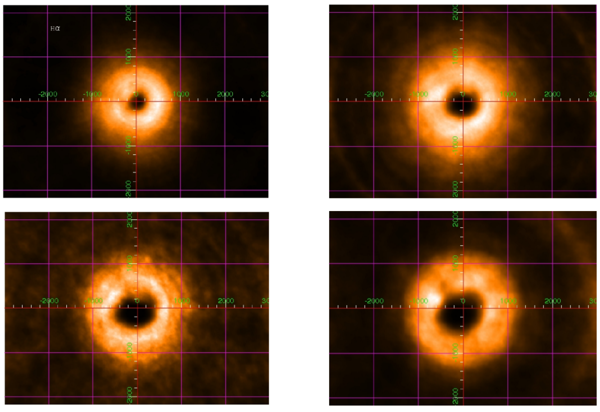

Fig3: Top, tomogram for Hα and Hβ. Bottom, He I(6678.149Å y 5875.618Å) tomogram.

Where did the data came from?

We use data from ESO's UVES spectrograph (cerro Paranal) acquired during March 10-11 11-12 2007. We obtained 147 spectra with 75000 pixels each, in the range 4800 Å to 6800 Å. We reduced them using the UVES pipeline
For orbital period calculations, we also use 8 archive spectra from the system taken by Makoto Uemura on April 22th 2006 with EMMI spectrograph (La Silla). We reduce them with IRAF. They cover the range 3662 Å to 5535 Å.

How to read a trailed spectra

Cataclismyc Variable Stars display a special spectroscopic characteristic: double-peaked emission lines due to Doppler effects on its accretion disc. We observe these peaks in our spectra as a pair of sinusoidal lines changing with orbital phase. Actually, each feature in the system will produce a particular so-called "s-wave". Most of the time our work is to "reverse engenieering" the s-waves to deduce which feature produced it.

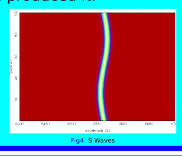

Fig4: S Waves

What is a Doppler tomogram?

The application of Doppler Tomography in cataclysmic variables was introduced by Marsh & Horne (1988). This is a method using which we recover two-dimensional velocity-maps from emission lines.
A double-peaked line offers a projection of the radial velocities distribution, whereas the rotation of the system gives a sequence of these projections.
These two variables deliver enough information to construct the map (or tomogram) from a set of spectra taken along an orbital cycle. With the Doppler map, we recover the aspect of the disc in velocity space.
It's not trivial to translate a Doppler map to position coordinates. Due to this we "read" the tomogram knowing that the disc is inverted (inside out) with respect to its real aspect.

Other parameters

By the diagnostic diagram method, we calculated the radial velocity of the primary star as K_1 of 73.3 (4.5) km/s. We also calculated the velocity of the centre of mass. It converges to γ=40.4 (3.4) km/s. After the zero phase correction, we found HJD0=2454170.80.
We constrained q and i by using Warner's formula for non eclipsing binaries, estimating an upper limit for a tidally limited disc and a lower one for the inviscid disc. We got q and i as q_{max}=0.54, i_{max}=74°and q_{min}=0.232 i_{min}=71°

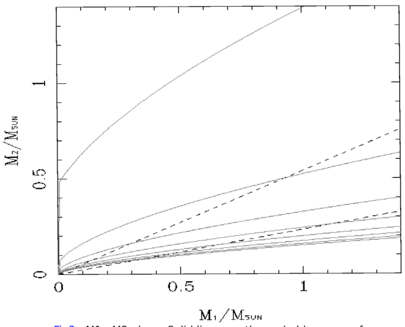

Fig3: M1 - M2 plane. Solid lines are the probable masses for a given angle of inclination. They start at 10° (bottom) and rise in steps of 10° up to 80° (top).

Discussion and Conclusions

Our orbital period, 0.06049 (10) d, is 1 σ off with respect to Patterson's period, who proposed a value of 0.06028 (10)d. Nevertheless, the values are compatible in the limit of 1.1σ which, added to the fact that Patterson's observations were carried out in conditions far from ideal, makes us confident in our result.
Before this research, there where 2 values for V1040 Cen component masses. Both values were courting q=0.136 (30), the original parameter estimated by Patterson. The figure 5 shows restrictions for the masses of the system found in this investigation, plotting our values obtained for q and the value estimated by Patterson. Patterson's value is the first one from the bottom up. Watching the figure, we see that q=0.136 would be near an angle of 80º, that is to say, the system would be eclipsing. This disparity might owe to Patterson' method to calculate the value of q, which as he indicates in his paper, is a rough approximation.

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