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NEW RADIAL VELOCITIES AND ORBITAL SOLUTION OF THE ACTIVE BINARY STAR AR LACERTAE

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AR Lacertae (HD 210334, BD +45°3813) is a photospherically and chromospherically active eclipsing binary star (see eg. Lanza et al., 1998 and references therein) composed of a G2 IV and a K0 IV star. The primary eclipse is an occultation with a well defined totality (Wood, 1946).

Although AR Lac is a very well-studied RS CVn star, there are very few determinations of orbital and physical parameters from radial velocity measurements, because the orbital period of this system is near exactly 2 days and it is very difficult to achieve a good phase coverage during an observational run. The only published solutions are those of Harper (1933) and Sanford (1951). The latter have been revised by Popper (1980, 1990). Recently Gunn et al. (1998) determined new radial velocities but values are clustered around two specific phases.

Spectroscopic observations were obtained at the *M. G. Fracastoro* station of Catania Astrophysical Observatory in 1994, 1996 and 1997 with the 91 cm telescope, using REOSC echelle spectrograph in the cross-dispersion configuration. This mode yields a resolution of about 0.46 Å. The spectrograph is fed by the telescope through an optical fiber (UV-NIR, $200\mu m$ core diameter) and is placed in a stable position on the first floor of the telescope building. The gravity independent position and the small temperature excursions (< 1 - 2 degrees) makes the spectrograph very suitable for accurate radial velocity measurements. In 1994 the spectra were recorded on a CCD camera with a 385×576 pixel chip from E.E.V., pixel-size $22\mu m$. In the other years a CCD with 800×1152 pixels and pixel-size of $22.5\mu m$ has been used. The signal-to-noise ratio ranged from about 40 to about 150, depending on atmospheric conditions. Two and four echelle orders around the Hα region were recorded with the small and large CCD respectively.

In addition to our target, we observed some radial velocity standard stars.

The data were reduced using the ECHELLE task of IRAF [1] data reduction package. The data were flat-field corrected using a tungsten lamp. The wavelength calibration is based on a Thorium-Argon lamp. Radial velocities were obtained by cross-correlating each order of AR Lac spectra with the corresponding order of the standard star ϵ Cygni.

[1] IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of University for Research in Astronomy, inc. (AURA) under cooperative agreement with the National Science Foundation.

This star was selected because it has been observed throughout all the observing seasons of AR Lac and its spectrum (K0 III) is similar to one of the components of the target. Its heliocentric radial velocity is −10.6 km/s (Evans, 1967). The goodness of ϵ Cygni as a standard and the stability of experimental apparatus were tested by means of primary standard stars observed in some night leading to an accuracy of ±0.4 km/s.

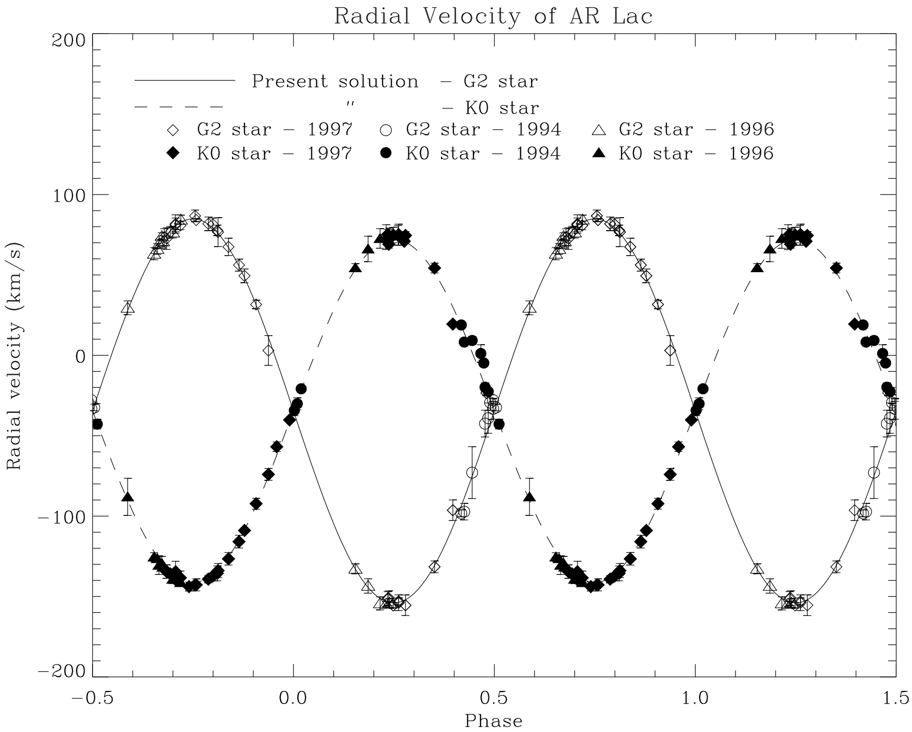

Figure 1. Radial velocity curve and best-fit solution of AR Lac

Spectral regions heavily affected by telluric lines (like the λ6276-λ6315 series of O_2) have been excluded in the cross correlation.

The evaluation of the standard errors in the radial velocities of AR Lac is a quite difficult task because of the rotationally broadened profiles of the two stars that are blended in some phases (in these cases we have used a two-gaussian fit to resolve the cross-correlation peak). The standard deviation of the values obtained from the different spectral orders has been taken as our better estimate of the errors in the RV measurements (error bars in Figure 1).

Due to the widely documented period variations (Lanza et al., 1998), we have used the ephemeris nearest to our observations to fold the data in phase.

The orbital phases for 1994 data have been reckoned by using the ephemeris:

$$HJD_{minI}=2447495.6369+1.983164\times\mathrm{E}\ \text{(Lanza et al., 1998)}$$

For the 1996 and 1997 data the new ephemeris obtained from UBV photometry performed at Catania with the 91 cm telescope in 1995 and 1997 (Marino – unpublished observations) has been adopted:

$$HJD_{minI}=2450692.5174+1.983188\times\mathrm{E}$$

The observational points and best-fit sinusoidal solution (eccentricity equal to 0) are plotted in Figure 1.

In Table 1 we report the orbital and physical parameters for our and Popper's (1990) solution. The most apparent discrepancy with respect to the old solutions of Harper (1933) and Sanford (1951) is the mass-ratio which is significantly different from unity. The more evolved K0 IV star results to be more massive than the companion, consistently with a normal evolution of the two stars.

Table 1. Orbital elements of AR Lacertae

Element	Present solution	Popper (1990) solution	
		absorption	emission
K_h	119.43 ±0.49 km/s	116.5	117.4 km/s
K_c	106.73 ±0.29 km/s	113.1	106.7 km/s
γ	−34.54 ±0.5 km/s		
γ_h		−34.6	−38.5 km/s
γ_c		−31.7	−37.6 km/s
$a_h \sin i$	$3.257 \pm 0.013 \times 10^6$ km	3.2×10^6	3.1×10^6 km
$a_c \sin i$	$2.911 \pm 0.008 \times 10^6$ km	3.1×10^6	2.9×10^6 km
$m_h \sin^3 i$	$1.122 \pm 0.008 M_\odot$	1.22	1.06 $M_\odot$
$m_c \sin^3 i$	$1.255 \pm 0.011 M_\odot$	1.26	1.12 $M_\odot$
m_h/m_c	0.894 ±0.006	0.97 ±0.03	0.94 ±0.02

Note: h: hotter, c: cooler

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