A New Absorption-Line Orbit for the Symbiotic Nova AG Pegasi

M. H. Slovak
University of Wisconsin, Madison, Wisconsin, USA

D. L. Lambert
University of Texas, Austin, Texas, USA

ABSTRACT. Precise cross-correlation absorption-line velocities have been derived using high resolution near infrared coude' spectra for the symbiotic nova AG Pegasi. A revised weighted orbital solution is presented based on both extant photographic and the new absorption-line velocities.

1. Orbital Studies of AG Pegasi

The pioneering work of Merrill (1951) clearly illustrated the complex velocity variations of the rich emission-line spectrum of AG Pegasi = HD 207757 which followed an approximate period of 800 days. Cowley and Stencel (1973) presented the first orbital solution for AG Peg based on twelve velocities measured from coude' spectra near Hα and nine determinations from Merrill (1951, 1959). Adopting a mass ratio $q = 3$ and assuming an inclination i = 36 degrees, they concluded that the M giant secondary did not fill its Roche lobe. An additional analysis was performed by Hutchings, Cowley and Redman (1975) with eleven new absorption-line velocities. They adopted an orbital period P = 820 days and argued that the hot primary was ejecting a mass stream towards the cool secondary. A large phase shift of $\Delta\phi = 0.20P$ was found for the Balmer lines between their data and the earlier Merrill velocities, and similar phase shifts appeared for other emission-line velocities as well. In order to clearly address these interesting features, we have obtained a series of high resolution digital coude' spectra over a complete orbital cycle and have derived precise ($\delta v = \pm$ 1.2 km/s) absorption-line velocities from infrared spectra near 8400 A.

2. New High Resolution Data

2.1. Digital Reticon Spectroscopy

Over 60 high resolution (0.2 A) coude' spectra of AG Pegasi were obtained using the 2.7m McDonald Observatory Reticon spectrograph (Vogt, Tull and Kelton 1978) from 1977 to late 1980, covering one complete orbital cycle (820 days). Four spectral regions were chosen, centered on 4684 A, 5007 A, 6563 A, and 8410 A, which include both the prominent emission features of He II, [O III], Hα as well as strong absorption lines from Ti I and Fe I (Fig. 1). Simultaneous observations of selected late-type giants with *a*-quality velocities were also obtained and used as templates to derive cross-correlation velocities.

2.2. Cross-correlation Radial Velocities

An automated cross-correlation method was developed to derive high precision absorption-line velocities (Slovak 1982). Discrete cross-correlation functions (DCCF) are calculated for each program-standard star pair and fit with numerical cubic splines rather than an imposed functional form. The first derivative of the spline yields the

J. Mikolajewska et al. (eds.), The Symbiotic Phenomenon, 265–267.

zero crossing, providing the maximum of the DCCF to a fraction of a diode. Cross-correlation velocities determined in this way were independently verified against conventionally measured velocities using Fe-Ne comparison spectra. The mean of the residual velocities between the two methods is -0.98 ± 0.71 km/s and is dominated by the uncertainties in the adopted velocities for the *a*-quality standards (±0.5 km/s).

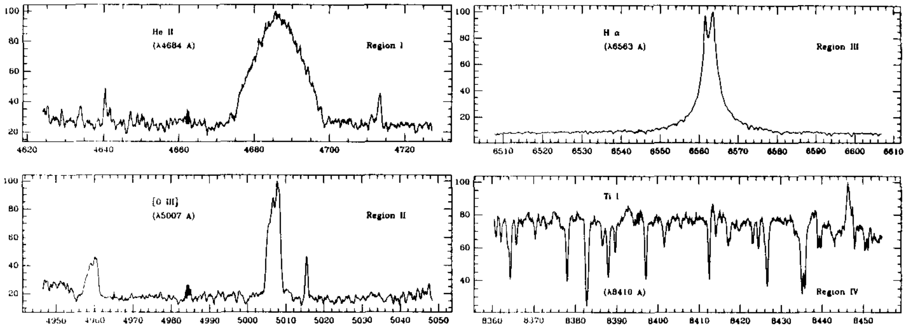

Figure 1. High resolution Reticon spectra of AG Peg. Strong emission lines dominate Regions I - III and the absorption lines are veiled. The majority of the absorption-line velocities were derived from Region IV data, clearly showing strong, uncontaminated absorption features of Fe I and Ti I.

3. Revised Orbital Solution

Using absorption-line velocities from Merrill (1959), Cowley and Stencel (1973), and Hutchings, Cowley and Redman (1975), in addition to the new data, orbital elements were calculated using a modified Wilsing-Russell code, which has been enhanced to accomodate large eccentricities and which performs differential correction of the preliminary elements. The best determined photometric period P = 816.5±0.9, based on an extensive analysis of photoelectric data (Fernie 1985), was adopted as the initial orbital period.

The observed velocities and the orbital solution are seen in Figure 2. The mean residual velocity of the data about the calculated curve is -0.21 km/s with a standard deviation of 2.24 km/s. The relatively large scatter reflects either intrinsic velocity variations or is due to the larger errors associated with the photographically determined velocities. Final orbital elements are presented in Table 1 and are compared to the previous solution from Cowley and Stencel (1973).

4. References

Cowley, A. , and Stencel, R. 1973, *Ap. J.*, **184**, 687.
Fernie, J. D. 1987, *Pub. A. S. P.*, **97**, 653.
Hutchings, J. B., Cowley, A. P., and Redman, R. O. 1975, *Ap. J.*, **201**, 404.
Merrill, P. W. 1951, *Ap. J.*, **113**, 605.
------------. 1959, *ibid*, **129**, 44.
Slovak, M. H. 1982, PhD Thesis (University of Texas: Austin).
Vogt, S. S., Tull, R. G., and Kelton, P. W. 1987, *Applied Optics*, **17**, 574.
Wilson, R. E. 1953, *General Catalogue of Stellar Radial Velocities* (Washington: Carnegie), Publication **601**.

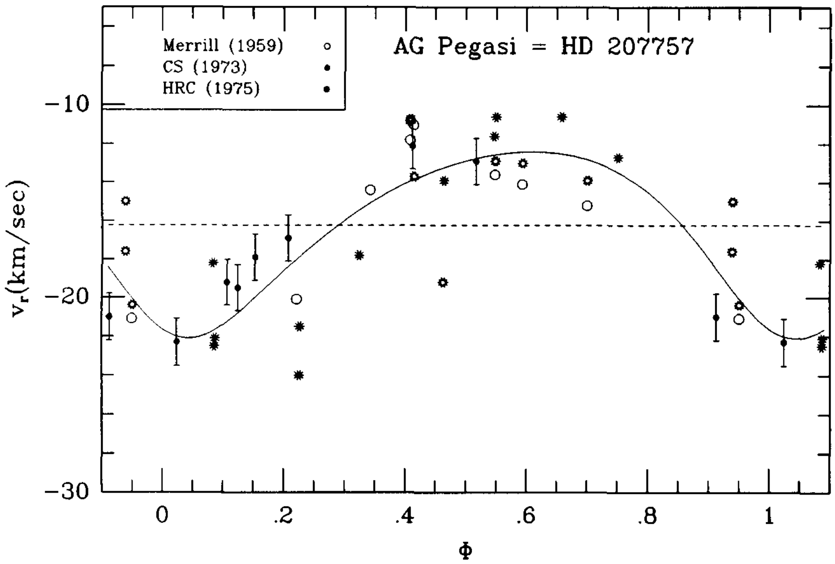

Figure 2. Absorption-line radial velocities and calculated orbit (solid line) for AG Peg. The systemic velocity is also indicated (dashed line). Photographic velocities are shown as various symbols, identified in the legend. New cross-correlation velocities are seen as filled symbols with 1σ error bars.

Table I

Orbital Elements for the Symbiotic Nova AG Pegasi

P (days)	818.72 ± 2.5[1]	830.14 ± 1.68[2]
K (km/s)	4.98 ± 0.37	5.6 ± 0.2
γ (km/s)	-16.15 ± 0.28	-16.8 ± 0.2
e	0.28 ± 0.08	0.25 ± 0.05
Ω (°)	149.9 ± 20.2	251.1 ± 3.2
T_0 (days)	2444507.8 ± 33.9	2439045.99 ± 24.98
a sin(*i*) (10^7 km)	5.42 ± 0.13	6.19
f (M) ($M_\odot$)	0.009	0.014

---

[1] Present solution.

[2] Cowley and Stencel (1973).