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PHOTOMETRIC INVESTIGATION OF THE NEBULA IN THE AG Peg SYSTEM

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The AG Peg (HD 207 257) system is the oldest known symbiotic nova. Its hot secondary has undergone a single outburst and a high velocity stellar wind has appeared as a result of it. The view this system is at a stage of colliding winds in its evolution is now commonly accepted (Penston & Allen 1985, Kenyon et al. 1993, Tomov 1993, Vogel & Nussbaumer 1994, Altamore & Cassatella 1997). The UV data show that the luminosity and the mass-loss rate of the hot component gradually decrease (Mürset et al. 1991, Kenyon et al. 1993, Vogel & Nussbaumer 1994, Altamore & Cassatella 1997). According to the photometric observations, the visual flux of the system gradually decreases too, although its orbital amplitude remains invariable (Belyakina 1992). In this note we compare two values of the U flux taken in the photometric maximum and separated by four orbital cycles ($\sim 3290^{\rm d}$). We consider the possible relation between their difference and the variation of the luminosity and the mass-loss rate of the hot component.

Our observations (Table 1) were performed during September 1995 – January 1998 with a single channel photoelectric photometer, mounted at the Cassegrain focus of the 0.6 m F/12.5 telescope of the National Astronomical Observatory Rozhen. We obtained 20 UBV estimates during one orbital cycle (Fig. 1). On JD 2 450 476.2 only B and V estimates were taken. The star BD+11°4681 having $V = 8\overset{\rm m}{.}18$, $B - V = 1\overset{\rm m}{.}03$ and $U - B = 0\overset{\rm m}{.}81$ (Belyakina 1992) was used as a comparison star. The m.s. errors are not larger than $0\overset{\rm m}{.}01$ in V and B, and $0\overset{\rm m}{.}02$ in U.

The decrease of the visual light of AG Peg is caused by the decreasing contribution of its circumbinary nebula as the cool component of this system does not change and the hot one has temperature about 90 000 K (Mürset et al. 1991, Kenyon et al. 1993, Altamore & Cassatella 1997) radiating mostly in UV. We will treat the light in the U region where the Balmer continuum of the nebula is radiated and the cool component's spectrum is absent.

The U magnitudes of the AG Peg system on JD 2 446 761.2 (26. Nov, 1986) and JD 2 450 049.3 (27. Nov, 1995) are $8\overset{\rm m}{.}54$ (Belyakina 1992) and $9\overset{\rm m}{.}03$ respectively. The corresponding continuum fluxes are equal to 2.84×10^{-12} erg cm^{-2} s^{-1} Å^{-1} and 1.81×10^{-12} erg cm^{-2} s^{-1} Å^{-1} which were corrected for interstellar reddening by means of the value $E(B - V) = 0.12$ (Penston & Allen 1985) using the extinction law by Seaton (1979). The spectrum of the nebula is formed by the winds of the two stellar components and is ionized by the radiation of the hot secondary beyond the limit of Lyman series. The velocity of the wind of the giant is 20 km s^{-1}, its mass-loss rate is 2×10^{-7} $M_\odot$ yr^{-1} (Vogel

& Nussbaumer 1994, Mürset et al. 1995) and does not vary. Therefore the change of the nebular spectrum is probably due to a change of the hot stellar component and its wind. The radius of this component at the two times considered by us was equal to 0.11 $R_\odot$ and 0.09 $R_\odot$ respectively. These values are arithmetical means of the data of Vogel & Nussbaumer (1994) and Altamore & Cassatella (1997). The second of them was calculated using the value of Vogel & Nussbaumer for the year 1993 as their observations were up to this moment. Thus the Lyman photon luminosity of the hot component was 1.80×10^{46} photons s^{-1} and 1.21×10^{46} photons s^{-1}. The intensity of the nebular continuum is proportional to the ion density. There is, also, linear dependence between the ion density and the density of the radiation field of the ionizing star. In such a case the Lyman photon luminosity will change in the same ratio like the continuum flux at the maximal sensitivity of the U photometric system. It was found that the Lyman luminosity decreasing of 33 % is in agreement with the decreasing of the U flux, which is equal to 36 %.

There is also in the AG Peg system a wind shed by its hot component and its mechanical energy must be considered too. The two winds collide head on, creating a collision region with a small thickness, as described in the very simplified approximation by Girard & Willson (1987). Let us consider every one of these parts of the circumbinary nebula. The hot wind has had a constant velocity of 1000 km s^{-1} (Tomov et al. 1998) during the period treated, but the mass-loss rate of the hot secondary has decreased from 1.48×10^{-7} $M_\odot\,yr^{-1}$ to 7.98×10^{-8} $M_\odot\,yr^{-1}$. These values are arithmetical means of the estimates of Vogel & Nussbaumer (1994) and Altamore & Cassatella (1997). We calculated the continuum flux at the wavelength λ 3650 Å determined by recombinations and free-free transitions in the hot wind for the two moments, considered by us, allowing helium abundance 0.1 and a distance to the system equal to 650 pc (Mürset et al. 1991, Vogel & Nussbaumer 1994, Mürset et al. 1995, Altamore & Cassatella 1997). It turned out that the contribution of this radiation in the U flux of the whole system is negligible and is equal to about 4 % and 2 % respectively. That is why the observed variation of the U flux is not due to the decreasing contribution of the hot wind. In such a case the U light of the AG Peg system probably appears mostly in the collision region of the winds.

Table 1. Photometric observations of AG Peg

JD–2449000	n	V	B	U	JD–2449000	n	V	B	U
974.3	3	8.56	9.76	9.16	1398.2	3	8.85	10.22	10.32
988.4	2	8.55	9.73	9.13	1434.2	1	8.88	10.19	10.21
993.4	2	8.55	9.71	9.09	1476.2	1	8.86	10.18	—
996.4	2	8.58	9.76	9.10	1628.5	3	8.80	10.03	9.75
1012.3	2	8.56	9.75	8.97	1651.5	2	8.74	9.98	9.61
1024.3	2	8.56	9.69	9.08	1698.4	3	8.70	9.89	9.41
1049.3	2	8.56	9.71	9.02	1701.4	2	8.69	9.90	9.42
1092.2	3	8.61	9.76	9.12	1741.2	3	8.69	9.85	9.26
1267.4	2	8.77	10.07	9.95	1742.2	3	8.68	9.84	9.22
1295.4	3	8.75	10.08	10.03	1828.2	2	8.64	9.78	9.13
1297.4	2	8.78	10.08	10.08					

According to the theoretical approximation of Girard & Willson (1987) there are two mechanisms of ionization in this region: radiative one and shock one. The latter of them is determined by the sum of the kinetic energies of the winds. This sum in the two moments under consideration is calculated to be 4.69×10^{34} erg s^{-1} and 2.53×10^{34} erg s^{-1}. It has thus decreased with 46 %, which is also in agreement with the observed decreasing of the U flux.

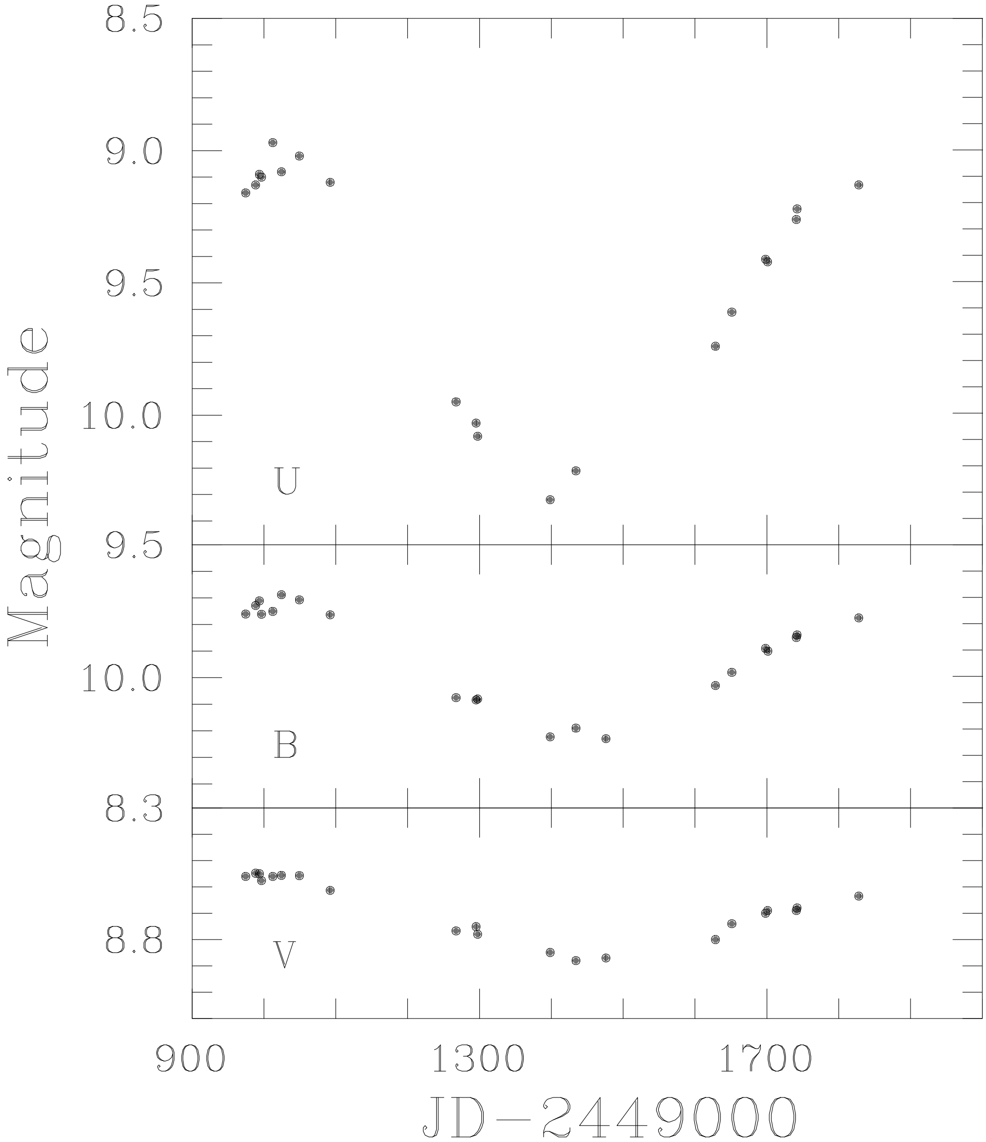

Figure 1. The UBV light curves of AG Peg

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