COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS

Number 3202

Konkoly Observatory
Budapest
14 June 1988

HU ISSN 0374-0676

AG VIRGINIS: NEW TIMES OF MINIMA AND PERIOD STUDY

Photoelectric observations of the eclipsing binary star AG Virginis (BD+13° 2481) were made on seven nights (Februrary, March and April 1987) using the one meter telescope at the Stephen F. Austin Observatory. The photometer was a Thorn EMI Gencom, Inc. "Starlight-1R" photon counting system equipped with an uncooled EMI 9798A S-20 response tube. Telescope positioning, photometer operation, and data logging was controlled automatically by a Commodore 64 microcomputer (Markworth and Rafert, 1985). Using the comparison star BD+13° 2485, 2,209 observations were obtained in the natural Blue, Visual, and Red bandpasses. These observations resulted in nearly complete BVR light curves and 15 new times of minimum light (12 primary and 3 secondary). The differential magnitudes were normalized and the resulting visual light curve is presented in Figure 1.

Determining accurate times of minimum light for AG Virginis is complicated by the asymmetries found in the eclipse branches and the distorted primary minimum. The light curve presented in Figure 1 shows a much smaller distortion in the primary minimum and a more symmetrical secondary eclipse than reported by past observers (Wood, 1946, Binnendijk, 1969, and Blanco and Catalano, 1970). Nightly variations at the bottom of primary eclipse were also evident in the new observations.

TABLE 1

JD HEL.	MIN	O-C	OBSERVER
2429329.8510	II	+.0144	WOOD(1946)
9334.9930	II	+.0152	WOOD(1946)
9335.9560	I	+.0142	WOOD(1946)
9337.8840	I	+.0142	WOOD(1946)
9338.8510	II	+.0172	WOOD(1946)
9339.8110	I	+.0133	WOOD(1946)
9346.8790	I	+.0121	WOOD(1946)
9359.7340	I	+.0141	WOOD(1946)
9363.9100	II	+.0129	WOOD(1946)
9368.7320	I	+.0150	WOOD(1946)
2433387.8540	I	-.0004	NASON AND MOORE(1951)
4086.4195	I	+.0039	KWEE(1958)
4120.4787	I	+.0026	KWEE(1958)
4455.2919	I	-.0052	SZCZEPANOWSKA(1958)
4458.5090	I	-.0014	SZCZEPANOWSKA(1958)
4487.4297	I	+.0000	SZCZEPANOWSKA(1958)
4776.6215	I	-.0010	SZCZEPANOWSKA(1958)
5197.5551	I	-.0036	SZCZEPANOWSKA(1958)
5198.5286	II	+.0059	SZCZEPANOWSKA(1958)
5219.4146	I	+.0058	SZCZEPANOWSKA(1958)
5561.2974	I	-.0016	SZCZEPANOWSKA(1958)
5562.2619	II	-.0010	SZCZEPANOWSKA(1958)
5848.5649	I	+.0011	SZCZEPANOWSKA(1958)
7028.4755	I	+.0050	PURGATHOFER AND WIDORN(1964)
8846.5350	I	+.0058	BLANCO AND CATALANO(1970)
9587.5065	I	+.0010	BLANCO AND CATALANO(1970)
9596.5040	I	+.0014	BLANCO AND CATALANO(1970)
2439618.3520	I	-.0007	BLANCO AND CATALANO(1970)
9643.4142	I	-.0019	BLANCO AND CATALANO(1970)
9943.8593	II	+.0040	BINNENDIJK(1969)
9944.8191	I	-.0002	BINNENDIJK(1969)
9946.7472	I	+.0000	BINNENDIJK(1969)
9948.6755	I	+.0003	BINNENDIJK(1969)
2441391.4270	I	+.0011	KIZILIRMAK AND POHL(1974)
2451.4800	II	+.0018	POHL AND KIZILIRMAK(1977)
2892.6620	I	+.0041	MALLAMA et. al.(1982)
4709.4356	I	+.0042	POHL et. al.(1977)
5741.2071	II	+.0000	KALUZNY(1987)
6855.8809	I	-.0038	MICHAELS
6855.8821	I	-.0026	MICHAELS
6855.8835	I	-.0012	MICHAELS
6859.7363	I	-.0043	MICHAELS
6859.7381	I	-.0025	MICHAELS
6859.7389	I	-.0017	MICHAELS
6860.7096	II	+.0051	MICHAELS
6860.7103	II	+.0058	MICHAELS
6860.7120	II	+.0075	MICHAELS
6875.8047	I	-.0021	MICHAELS
6875.8051	I	-.0017	MICHAELS
6875.8059	I	-.0009	MICHAELS
6911.7914	I	-.0039	MICHAELS
6911.7924	I	-.0029	MICHAELS
6911.7935	I	-.0018	MICHAELS

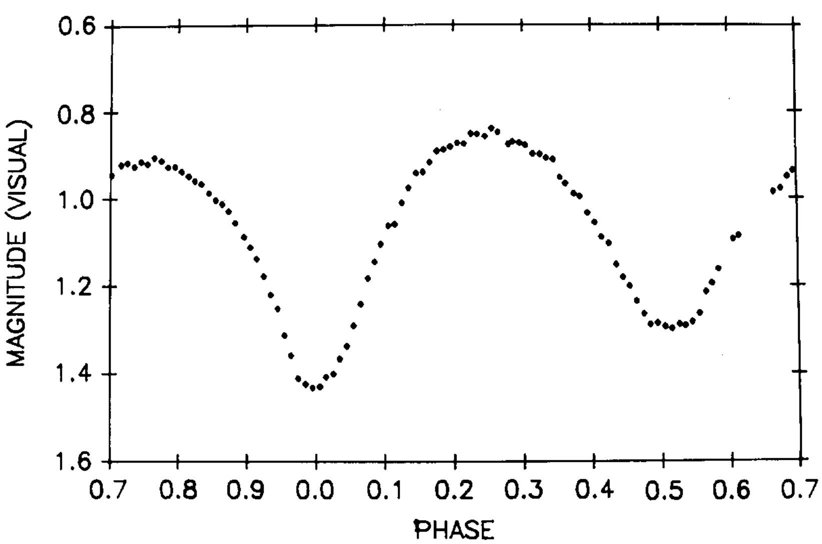

Figure 1
The normalized visual differential magnitudes of AG Virginis in the sense variable-comparison.

TABLE 2

OBS*	TIME	N (PRI)	O-C (PRI)	N (SEC)	O-C (SEC)	DIFF.	SECONDARY DISPLACEMENT
WO	MAR 1939-APR 1939	6	.0138	4	.0149	-.0011	1.6 MIN. LATE
SZ	APR 1955-MAR 1956	3	.0002	2	.0025	-.0023	3.3 MIN. LATE
BI	MAR 1968-APR 1968	3	.0000	1	.0040	-.0040	5.8 MIN. LATE
MI	MAR 1987-APR 1987	12	-.0025	3	.0061	-.0061	12.4 MIN. LATE

* WO = Wood (1946); SZ = Szczepanowska (1958); BI = Binnendijk (1969); Mi = Michaels

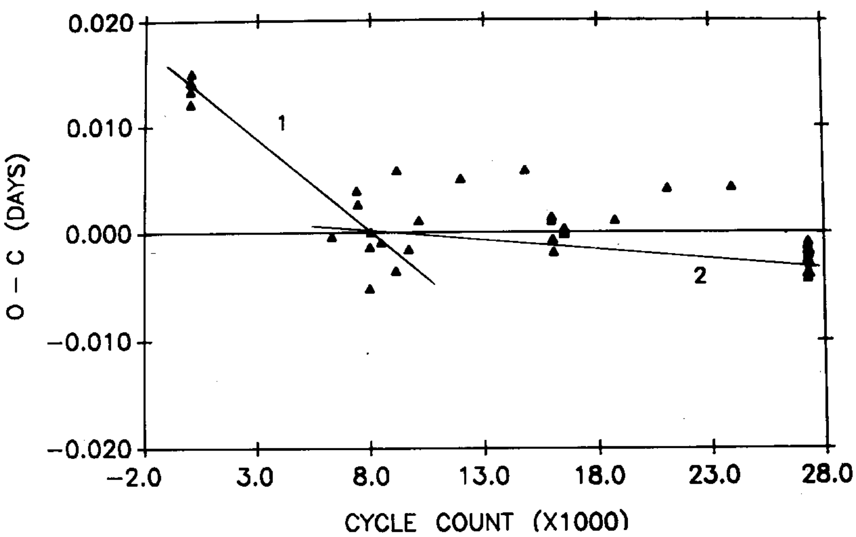

Figure 2

The O-C diagram for AG Virginis using only photoelectric primary minima. Line Segment 1 and Segment 2 illustrate a possible period change.

Photoelectric minima for this star typically show a significantly smaller scatter in the O-C diagram compared to those determined from visual and photographic observations. Only photoelectric minima are, therefore, compiled in Table 1 and used in this period study. The new times of minimum in this paper were determined by using a FORTRAN program that applied a parabolic least squares fit to the branches of each eclipse (the lower part of primary minimum was not used because it was clearly distorted). The new times of minima are contained in Table 1.

Another interesting feature of the light curve is the displaced secondary eclipse, which was reported in previous studies (Binnendijk, 1969, Blanco and Catalano, 1970). Since a displaced secondary minimum will affect the accuracy of a period study, an effort was made to determine whether the displacement is a permanent feature of the light curve. A good method for measuring a change in the phase of the secondary minimum would be to difference the observed minus the calculated (O-C) times of the primary eclipse with the observed minus the calculated (O-C) times of the secondary eclipse. By computing the O-C's at several epochs (using the same orbital period) any change in secondary displacement would become apparent. For a circular orbit where primary eclipse occurs at 0.0 phase and secondary at 0.5 phase the difference should be zero. In Table 2 the minima of four different observers were used in the procedure outlined above. TIME is the calendar dates for each set of observations. $(O-C)_{pri}$ and $(O-C)_{sec}$ are the average residuals (O-Cs) for primary and secondary eclipse respectively. N_{pri} and N_{sec} are the number of minima used to compute each average O-C. The period used to form the O-C's was computed using Binnendijk's ephemeris (1969)

$$\text{Hel. JD(Min)} = 2439946.7472 + 0\overset{d}{.}64265068E.$$

The difference in primary and secondary O-Cs indicates the displacement of the secondary eclipse has been increasing and is presently (April 1987) occuring 12.4 minutes late! The displaced secondary minimum is most likely the result of inaccurate times of minimum light due to distortions in the light curve. The distortions may affect both primary and secondary eclipses. A period study of AG Virginis should, therefore, use either primary minima or secondary minima but not both.

Table 1 lists the Heliocentric Julian Date of each minimum, the O-C in days using Binnendijk's (1969) linear ephemeris, the type of minimum (primary or secondary) and the reference. Figure 2 is the O-C diagram using only the primary minima from Table 1. Despite the large scatter in the residuals it seems likely that one period change may have occured as first reported by Binnendijk (1969). The two line segments in Figure 2 represent the best linear fits before and after the period change. Using the primary minima only a least squares solution for the initial epoch and the period for each segment is given by,

$$\text{SEGMENT 1} \quad \text{Hel. JD(Min)} = \underset{.0015}{2429335.9547} + \underset{.000000211}{0^{d}\!.642649295}E$$

$$\text{SEGMENT 2} \quad \text{Hel. JD(Min)} - \underset{.0008}{2433387.8556} + \underset{.000000059}{0^{d}\!.642650549}E$$

The period increase amounted to only 0.11 seconds. Segment 2 gives the best current light elements for AG Virginis.

Another period study by Blanco and Catalano (1970) suggests the orbital period of AG Virginis undergoes a slow variation with a period of about 40 years. Considering the scatter in the O-C diagram (Figure 2) this conclusion is far from secure. A period variation on this time scale is unlikely given the short orbital period and the lack of any observed periodic displacement of the secondary minimum about 0.5 phase which would suggest apsidal motion. A complete discussion and light curve analysis of AG Virginis will be published elsewhere.

E.J. MICHAELS
Stephen F. Austin State University
Department of Physics and Astronomy
Box 13044
Nacogdoches, TX 75962 USA

References:

Binnendijk, L., 1969, A.J. 74, 1024.
Blanco, C. and Catalano, F., 1970, Mem.S.A.I. 41, 343.
Kaluzny, J., 1987, Preprint.
Kizilirmak, A. and Pohl, E., 1974, I.B.V.S. No. 937.
Kwee, K.K., 1958, Bull.Astron.Inst.Neth. 14, 131.
Mallama, A.D., Skillman, D.R., Pinto, P.A., Krobousek, B.A., 1977, I.B.V.S. No. 1249.
Markworth, N.L. and Rafert, J.B., Microcomputers In Astronomy, Fairborn Press, 1985.
Nason, M.E. and Moore, R.C., 1951, A.J. 56, 183.
Pohl, E., Evren, S., Tumer, O., Sezer, C., 1982, I.B.V.S. No. 2189.
Pohl, E. and Kizilirmak, A., 1976, I.B.V.S. No. 1163.
Purgathofer, A. and Widorn, T., 1964, Mitt. Wien 12, 31.
Szczepanowska, A., 1958, Acta Astron. 8, 36.
Wood, F.B., 1946, Contrib. Princeton Univ. Obs., No. 21, 4.