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Remarkable yellow supergiant variable TmzV429

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Abstract

We discovered that GSC 6554.559 is a previously unknown variable star, and named as TmzV429. We noticed that TmzV429 is identified with the IRAS-selected proto-planetary nebula (PPN), IRAS 08005-2356, which is undergoing a vigorous mass-loss episode. The analysis of photometric data suggests that TmzV429 a short-period pulsator, resembling a high-latitude yellow supergiant variable. TmzV429 is considered to be one of rare objects caught in the rapid course of PPN evolution, and shows one of the most striking mass-loss features among variable stars in the PPN stage. Since its evolutionary time-scale is estimated to be quite short ($\sim$150 yrs), future observations of pulsations of TmzV429 is expected to provide an excellent opportunity to study the stellar evolution in real time.

1 Introduction

Proto-planetary nebulae (PPNe) are objects in transition between the AGB stage and planetary nebula (PN) stage in stellar evolution (for a review, see Hrivnak (1997)). PPNe are astrophysical objects not only important in studying the mass-loss from post-AGB stars and the formation of PNe, but also are considered to related to some of enigmatic high-latitude luminous yellow variables, such as RV Tau stars and UU Her stars (for a recent review, see Hrivnak & Lu (1997)).

Table 1: Observations of TmzV429 by Takamizawa

JD[a]	mag[b]	JD[a]	mag[b]	JD[a]	mag[b]	JD[a]	mag[b]
49668.224	11.7	50125.040	11.8	50735.306	11.8	51218.037	11.9
49769.035	12.1	50378.328	11.8	50786.225	12.0	51272.952	12.0
50040.235	11.7	50426.155	12.2	50814.172	11.9		
50074.213	11.7	50506.995	11.7	51133.285	12.1		

[a] JD−2400000.

[b] Photographic magnitude. Close to V+0.5.

TmzV429 (=GSC 6554.559)[1] is a variable star discovered by Takamizawa (1999). The J2000.0 coordinates are $08^h02^m40^s.71$, $-24^\circ04'42''.4$. Takamizawa (1999) reported small amplitude variations with a total photographic range of variability of 11.7–12.2. Takamizawa (1999) originally suspected that this star is an semiregular variable. We discovered that this variable star, inconspicuous at the time of the variability announcement, is identified with a conspicuously mass-losing central star of a PPN, IRAS 08005-2356. We describe in this paper the analysis of our photometric data and the astrophysical implications of the present identification with a rapidly evolving PPN.

2 Observations

The photographic observations by Takamizawa (Saku All Sky Survey, SASS) using 10-cm F/4.0 twin patrol cameras and T-Max400 120 emulsions. The magnitudes were determined by comparison with non-red GSC stars, whose zero-point offset from Tycho-2 V magnitudes have been estimated to be +0.5 mag. This offset is confirmed by comparison with a single point V-band CCD measurement (Kiyota, private communication). Since a constant offset does not affect the confirmation of the variability and period analysis, we use the original measurements in the following analysis. The typical error of single estimates is ∼0.2 mag, which will not affect the following discussion.

Table 1 lists all observations of TmzV429 by this observation. Figure ?? shows the overall light curve drawn from these observations.

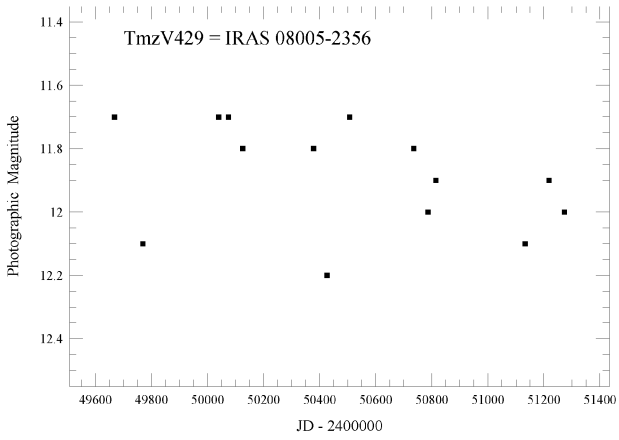

Figure 1 : Light curve of TmzV429 drawn from the data in table I

[1] The permanent designation V510 Pup has been given.

3 Discussion

We noticed that TmzV429 is identified with the PPN with a rapid mass-loss, IRAS 08005-2356 (Slijkhuis et al. (1991)). The object is also identified with an infrared source, MSX5C G242.3642+03.5822 Egan et al. (1999). The optical spectral classification by Slijkhuis et al. (1991) is a late F-supergiant with prominent hydrogen emission lines. Together with Takamizawa's discovery of optical variability, the object seems to be classified as an high luminosity yellow supergiant variable (SRD-type in the General Catalogue of Variable Stars).

Te Lintel Hekkert et al. (1999) also reported a possible brightening by a several tenths of magnitude since 1986. This possible variation seems to be more likely attributed to shorter time-scale variations discovered by us.

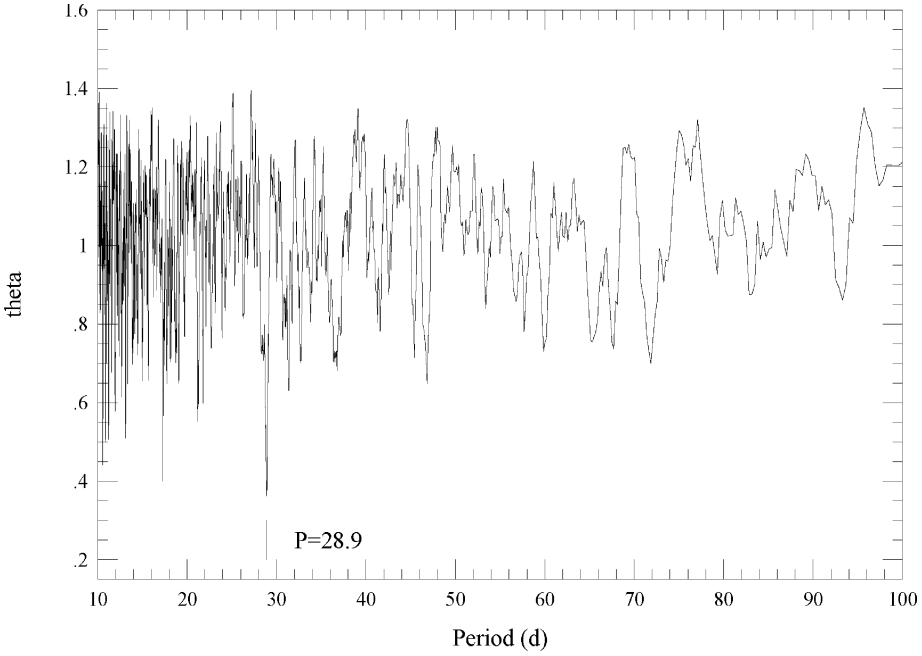

Figure 2 : Period analysis TmzV429. The most significant period of 28.9 d is marked with a tick.

We analyzed the original discovery data by Takamizawa (1999) using the Phase Dispersion Minimization (PDM) method (Stellingwerf (1978)). The result of period analysis are shown in figure 2. The period search was done for periods between 10 and 100 d. The range was limited mainly due to the data sampling, but covers most frequently met periods in low-mass, high luminosity, SRD-type variables. The strongest period between 10 and 100 d is 28.9 d. The period probably needs be treated with caution, because the period is close to the lunar month, and because of the possible intrinsic irregularity in such a variable. A rapid fading by 0.4 mag between JD 2450378 and 2450426, however, supports the existence of short-period variation with a period less than $\sim$100 d.

The folded light curve by this period is shown in figure 3. This result shows that the variability discovered by Takamizawa can be expressed by oscillations with a single, relatively short period. Although the possibility of a longer period can not be completely disregarded, the raw data (table 1) suggest a short-period variation, rather than a period of hundreds of days to years. Slijkhuis et al. (1991) reported some line features are similar to ρ Cas. The presently discovered variation, however, is not consistent with variations with a much longer period ($\sim$300 d) as in massive ρ Cas-like variables. The star should be thereby regarded as a low-mass, post-AGB pulsator (e.g. Aikawa (1991)), which is consistent with the evolutionary stage. Slijkhuis et al. (1991) inferred from

optical spectroscopy and IRAS observations.

Although the number of observations is still limited, and the present analysis unavoidably suffers from a uncertainty, the present result suggests the existence of a low-amplitude (∼0.5 mag), relatively short-period pulsations in TmzV429, which are analogous to variations observed in some stellar components of other PPNe and in high galactic luminous yellow variables, such as RV Tau stars and UU Her stars. Slijkhuis et al. (1991) suggested that the evolutionary time scale of this object is quite short (∼150 yrs). TmzV429 is thus one of rare objects caught in the rapid course of PPN evolution, and shows one of the most striking mass-loss features among variable stars in the PPN stage. Pulsations in such stars are a sensitive indicator of the evolution Aikawa (1991), future observations of pulsations of this object will provide an excellent opportunity to study the stellar evolution in real time.

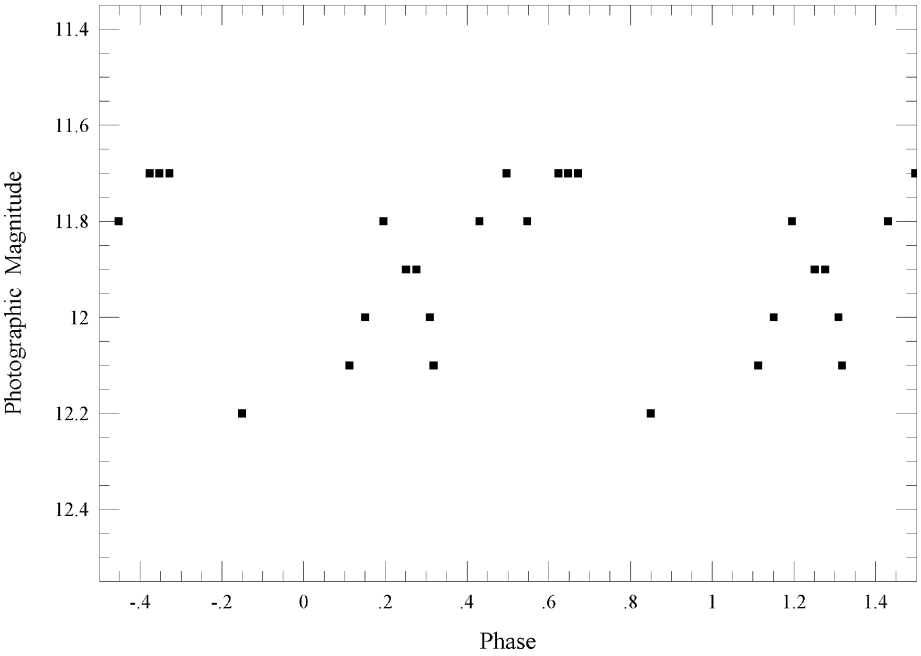

Figure 3 : Folded light curve of TmzV429. The phase zero is taken arbitrarily.

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Visual and CCD minima of eclipsing binaries during 2001

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Following table is summary of minima of eclipsing binary reported from VSOLJ members in 2001.

star	min. 2450000+		O-C	E		n	obs.	inst.
RT And	2452200.982		-0.004	17584	v	12	Hsk	28SC
V343 Aql	2452176.042		-0.037	12866	v	19	Hsk	28SC
V346 Aql	2452200.915		-0.007	9294	v	9	Hsk	28SC
ST Aqr	2452171.0012		-0.0293	14001	Rc	103	Nga	10L+CV-04
CX Aqr	2452194.0791		-0.0012	28311	Ic	130	Kis	25SC+AP-7
CX Aqr	2452217.986		-0.002	28354	v	12	Hsk	28SC
DD Aqr	2452176.9758		+0.1883	13243	V	80	Kis	25SC+AP-7
EE Aqr	2452175.0606	*1	+0.0059	22291.5	Rc	69	Nga	10L+CV-04
UW Boo	2452067.994		-0.027	9618	v	9	Hsk	28SC
RZ Cas	2452137.192		+0.024	7477	v	21	Sga	8B
RZ Cas	2452185.013		+0.035	7517	v	12	Mom	7B
RZ Cas	2452196.969		+0.039	7527	v	14	Hsk	5B
RZ Cas	2452202.947		+0.040	7532	v	47	Kit	7B
RZ Cas	2452210.1236		+0.0454	7538	v	24	Imm	7B
RZ Cas	2452217.292		+0.042	7544	v	13	Hsk	5B
RZ Cas	2452220.876		+0.041	7547	v	35	Kit	7B
RZ Cas	2452228.048		+0.041	7553	v	47	Kit	7B
RZ Cas	2452234.023		+0.040	7558	v	52	Kit	7B
RZ Cas	2452239.9999		+0.0405	7563	v	42	Imm	7B
RZ Cas	2452240.002		+0.043	7563	v	22	Edm	7B
RZ Cas	2452240.002		+0.043	7563	v	22	Kgb	7B
RZ Cas	2452240.006		+0.047	7563	v	22	Sst	7B
RZ Cas	2452240.006		+0.047	7563	v	22	Mom	7B
RZ Cas	2452240.006		+0.047	7563	v	15	Mkn	3.5B
RZ Cas	2452251.952		+0.040	7573	v	22	Ioh	6R
V523 Cas	2452176.134	*1	+0.061	46881.5	v	21	Mhh	20L
TY Cap	2452223.902		+0.042	5220	v	14	Hsk	28SC
BF Cap	2452100.1118	*1,2	-0.0049	6758.5	Rc	86	Nga	10L+CV-04
BF Cap	2452103.0465	*2	-0.0007	6764	Rc	87	Nga	10L+CV-04
BF Cap	2452104.1087	*2	-0.0031	6766	Rc	78	Nga	10L+CV-04
TT Cet	2452237.9623	*1	-0.0400	40522.5	Rc	115	Nga	10L+CV-04
TT Cet	2452245.9757		-0.0448	40539	Ic	71	Kis	25SC+AP-7
TT Cet	2452245.9758		-0.0448	40539	Rc	104	Nga	10L+CV-04
TW Cet	2452232.9966	*1	-0.0204	31117.5	Rc	71	Nga	10L+CV-04

star	min. 2450000+		O-C	E		n	obs.	inst.
VV Cet	2452176.1225		+0.0994	39908	Ic	87	Kis	25SC+AP-7
VY Cet	2452185.1064	*1	+0.0061	49165.5	Ic	124	Kis	25SC+AP-7
VY Cet	2452217.9951		+0.0066	49262	V	129	Kis	25SC+AP-7
YY Cet	2452176.0840		+0.4419	22231	Rc	64	Nga	10L+CV-04
DY Cet	2452194.085		-0.020	8380	Rc	23	Nga	10L+CV-04
RT CMa	2451940.1582		-0.6255	19567	V	102	Kis	25SC+AP-7
RT CMa	2452266.1807		-0.6336	19819	V	135	Kis	25SC+AP-7
RX CMa	2452270.1918		-0.1169	4764	Ic	196	Kis	25SC+AP-7
SX CMa	2451933.0491		+0.0331	14676	B,V	168	Kis	25SC+AP-7
CX CMa	2452244.2339		-0.0857	25297	Ic	167	Kis	25SC+AP-7
DE CMa	2451952.0155		-0.0029	34295	V	93	Kis	25SC+AP-7
XZ CMi	2451913.1335		-0.0128	16359	Rc	88	Nga	10L+CV-04
V Crt	2451984.0303		-0.0064	15080	Rc	88	Nga	10L+CV-04
Y Crv	2452004.1313		+0.0561	53320	Rc	82	Nga	10L+CV-04
RV Crv	2452035.9881	*1	-0.0457	14729.5	Rc	27	Nga	10L+CV-04
BR Cyg	2452163.995		-0.004	7973	v	13	Hsk	28SC
TT Del	2452168.979		-0.064	2416	v	12	Hsk	28SC
RU Eri	2451915.0174		-0.0238	15115	V	79	Kis	25SC+AP-7
RU Eri	2452244.0742	*1	-0.0268	15635.5	Ic	128	Kis	25SC+AP-7
UX Eri	2452233.0983		-0.1115	23156	Rc	43	Nga	10L+CV-04
UX Eri	2452235.0985	*1	-0.1150	23160.5	Rc	97	Nga	10L+CV-04
UX Eri	2452237.1055		-0.1118	23165	Rc	81	Nga	10L+CV-04
UX Eri	2452241.1144		-0.1104	23174	Ic	91	Kis	25SC+AP-7
UX Eri	2452254.9167		-0.1117	23205	Rc	105	Nga	10L+CV-04
VV Eri	2452175.2042		+0.0886	15943	Rc	52	Nga	10L+CV-04
YY Eri	2451911.001		+0.091	32129	v	95	Kit	12B
YY Eri	2451911.162	*1	+0.092	32129.5	v	95	Kit	12B
YY Eri	2452195.2031		+0.0927	33013	Rc	111	Nga	10L+CV-04
YY Eri	2452209.1904	*1	+0.0950	33056.5	V	376	Kis	25SC+AP-7
YY Eri	2452224.140		+0.095	33103	v	50	Kit	12B
YY Eri	2452230.090	*1	+0.098	33121.5	v	52	Kit	12B
YY Eri	2452238.124	*1	+0.094	33146.5	v	56	Kit	12B
YY Eri	2452240.0546	*1	+0.0958	33152.5	Rc	108	Nga	10L+CV-04
YY Eri	2452250.988	*1	+0.098	33186.5	v	41	Kit	12B
YY Eri	2452258.061	*1	+0.099	33208.5	v	59	Kit	12B
BC Eri	2452185.2119	*1*3	+0.0075	1297.5	Ic	162	Kis	25SC+AP-7
BC Eri	2452209.1996	*3	+0.0056	1343	Rc	81	Nga	10L+CV-04
BC Eri	2452241.0995	*1*3	+0.0073	1403.5	Rc	108	Nga	10L+CV-04
BC Eri	2452271.9410	*3	+0.0051	1462	Rc	55	Nga	10L+CV-04
BV Eri	2451912.9119		-0.0799	16671	Rc	87	Nga	10L+CV-04
BZ Eri	2452266.0565		+0.0034	40212	Rc	84	Nga	10L+CV-04
AE For	2452235.0140		-0.1059	4067	Ic	180	Kis	25SC+AP-7
AE For	2452240.9825	*1	-0.1058	4073.5	Ic	76	Kis	25SC+AP-7
AE For	2452258.886		-0.1074	4093	Rc	62	Nga	10L+CV-04
SZ Her	2452115.053		-0.024	12530	v	13	Hsk	28SC
CT Her	2452163.988		-0.009	5397	v	14	Hsk	28SC
u Her	2452017.10		-0.01	22519	v	9	Sga	5B
DF Hya	2451915.119	*1	-0.027	62846.5	Rc	66	Nga	10L+CV-04
DF Hya	2451915.2775		-0.0334	62847	Rc	66	Nga	10L+CV-04
DF Hya	2451939.0841		-0.0299	62919	Rc	58	Nga	10L+CV-04
DF Hya	2451940.0787		-0.0271	62922	Rc	90	Nga	10L+CV-04
DK Hya	2451982.0320		-0.1070	39858	V	164	Kis	25SC+AP-7

star	min. 2450000+		O-C	E		n	obs.	inst.
EU Hya	2451951.1819		-0.0188	22905	V	72	Kis	25SC+AP-7
FG Hya	2451950.0564		-0.0581	21297	Rc	51	Nga	10L+CV-04
FG Hya	2451958.0953	*1	-0.0511	21321.5	Rc	81	Nga	10L+CV-04
SW Lac	2452169.009	*1	-0.074	21494.5	v	10	Hsk	28SC
VX Lac	2452175.025		+0.040	6437	v	16	Hsk	28SC
UV Leo	2452231.294		+0.019	22981	v	36	Kit	12B
UV Leo	2452237.296		+0.020	22991	v	41	Kit	12B
UV Leo	2452259.202	*1	+0.023	23027.5	v	37	Kit	12B
AM Leo	2451974.1251		-0.0009	25918	V	263	Kis	25SC+AP-7
AP Leo	2452000.9538		-0.0354	28963	Rc	139	Nga	10L+CV-04
AP Leo	2452008.0527	*1	-0.0374	28979.5	Rc	57	Nga	10L+CV-04
V Lep	2452258.0137		+0.2313	31197	Rc	129	Nga	10L+CV-04
RR Lep	2451913.0717	*1	+0.0083	23525.5	V	128	Kis	25SC+AP-7
delta Lib	2451930.345		+0.022	3854	v	30	Kit	5B
delta Lib	2451937.315		+0.010	3857	v	39	Kit	3.5B,5B,7B
delta Lib	2451951.279		+0.010	3863	v	44	Kit	3.5B,5B,7B
TT Lyr	2452176.015		-0.015	2588	v	19	Hsk	28SC
TT Lyr	2452217.966		-0.014	2596	v	12	Hsk	28SC
beta Lyr	2452161.00		+6.01	3400	v	10	Sga	5B,8B
RW Mon	2451916.0100		-0.0405	9567	B,V,Ic	181	Kis	25SC+AP-7
RW Mon	2452259.1045		-0.0430	9747	Rc	107	Nga	10L+CV-04
BO Mon	2451921.0816		-0.0696	3781	V	151	Kis	25SC+AP-7
BM Mon	2451930.9975		+0.0280	19660	V	67	Kis	25SC+AP-7
DD Mon	2451925.0552	*1	+0.1205	38033.5	V	146	Kis	25SC+AP-7
ER Ori	2452232.1584		+0.0294	25049	Ic	216	Kis	25SC+AP-7
FZ Ori	2451934.1330		-0.0603	19775	V	97	Kis	25SC+AP-7
FZ Ori	2452230.1220		-0.0614	20515	V	134	Kis	25SC+AP-7
FZ Ori	2452238.1218		-0.0613	20535	Rc	49	Nga	10L+CV-04
GG Ori	2452247.0597	*1	-0.4457	2812.5	Ic	111	Kis	25SC+AP-7
V1353 Ori	2452259.0435	*4	+0.0596	4579	Ic	253	Kis	25SC+AP-7
V1363 Ori	2452237.2413	*1	+0.0625	8652.5	Ic	133	Kis	25SC+AP-7
V502 Oph	2452043.1141	*1	-0.0892	23972.5	Rc	152	Nga	10L+CV-04
V839 Oph	2452093.0729		+0.1542	28471	Rc	83	Nga	10L+CV-04
UX Peg	2452197.010		+0.005	7621	v	15	Hsk	28SC
RT Per	2452231.948		+0.052	22199	v	12	Hsk	28SC
beta Per	2452176.153		+0.053	2279	v	38	Imm	E
beta Per	2452196.220		+0.049	2286	v	42	Kit	E
beta Per	2452239.236		+0.055	2301	v	59	Kit	E
beta Per	2452242.0753		+0.0273	2302	v	24	Imm	E
beta Per	2452242.086		+0.038	2302	v	29	Ssu	E
RW PsA	2452175.9821	*1	-0.0228	49514.5	Rc	43	Nga	10L+CV-04
RW PsA	2452177.0671	*1	-0.0192	49517.5	V	78	Kis	25SC+AP-7
Y Psc	2452214.0278		-0.0081	1747	Ic	172	Kis	25SC+AP-7
VZ Psc	2452209.0617		+0.0823	32072	Ic	176	Kis	25SC+AP-7
VZ Psc	2452217.9438		+0.0840	32106	Rc	113	Nga	10L+CV-04
VZ Psc	2452229.9606		+0.0863	32152	Rc	33	Nga	10L+CV-04
VZ Psc	2452232.9708	*1	+0.0928	32163.5	Ic	113	Kis	25SC+AP-7
VZ Psc	2452237.0166		+0.0902	32179	Ic	109	Kis	25SC+AP-7
XZ Pup	2452236.2617		+0.0881	4481	Ic	79	Kis	25SC+AP-7
AV Pup	2452237.2300		+0.0026	37853	Rc	99	Nga	10L+CV-04
AY Pup	2451927.1800	*1	-0.0472	24046.5	V	88	Kis	25SC+AP-7
BD Scl	2452185.0683	*1	+0.0179	6506.5	Rc	120	Nga	10L+CV-04

star	min. 2450000+		O-C	E		n	obs.	inst.
CW Sct	2452092.0310		-0.0945	13500	Rc	38	Nga	10L+CV-04
CC Ser	2452016.1524	*1	-0.0222	28167.5	C	46	Njh	25SC+CV-04
Y Sex	2451949.7802	*1	+0.0605	24256.5	V	112	Kis	25SC+AP-7
U Sge	2452200.932		-0.024	10374	v	15	Hsk	28SC
RW Tau	2452224.030		-0.164	2362	v	24	Hsk	28SC
X Tri	2451915.884		-0.042	9689	v	11	Hsk	28SC
AA UMa	2452016.0209		+0.0206	24248	C	31	Njh	25SC+CV-04
UW Vir	2452042.992		-0.028	4251	v	18	Hsk	28SC
MS Vir	2452021.9909		-0.0288	11272	Rc	109	Nga	10L+CV-04
MS Vir	2452022.1393	*1	-0.0366	11272.5	Rc	109	Nga	10L+CV-04
Z Vul	2452124.031		+0.010	3738	v	13	Sga	10R
AW Vul	2452174.978		-0.002	7303	v	13	Hsk	28SC

*1 secondary minimum
*2 min(1) = 2448500.0260 + 0.532676 x cycle (Hipparcos calalogue)
*3 min(1) = 2451501.10674970 + 0.5272429 x cycle (IBVS 4937)
*4 min(1) = 2450100.26059 + 0.4714399 x Cycle (IBVS 4333)

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