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LONG-TERM VARIATION STUDY OF CATACLYSMIC VARIABLES WITH PALOMAR TRANSIENT FACTORY

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ABSTRACT

The Palomar Transient Factory is a project making use of a Schmidt 48 inch telescope located on the Palomar Mountain, which is surveying the sky with dynamical cadences. It was deployed in 2009 and the observed sky region is over 1200 square degrees. We have studied the long-term periodic variabilities of the known galactic cataclysmic variables (CVs). More than 20 of the sources had been found to have long term periodic signals, ranging from several tens of days to several hundreds of days. Some possible scenarios are proposed to explain the results, such as a magnetic field change of the companion star, precession of the accretion disk, triple systems and superoutburst cycles. Some preliminary discussion will be presented in this article.

Key words: close binary: cataclysmic variable: long-term variation

Table 1
Comparison of Some Major Sky Survey Projects

Name	D (m)	FoV (deg^2)	Cadence	$m_{R,\mathrm{lim}}$	Coverage (deg^{2}n^{-1})
PTF	1.26	7.78	dynamic	20.5	1000
SDSS-SN	2.5	1.5	2 d	22.6	150
PS1 3π	1.8	7	> 10 d	21.5	6000
CRTS	0.7	8	various	19.5	1200
LSST	8.4	9.62	3 d	24.5	3300

1. PALOMAR TRANSIENT FACTORY

Palomar Transient Factory (PTF) is a synopitc sky survey project. Universities in Taiwan (NCU and NTHU) as part of the University System of Taiwan (UST) members joined the project in 2010. It makes use of a 48 inch Schmidt telescope (P48) in Palomar Observatory. A wide field of view and dynamical cadence and its observation schedule made it a competitive project. The comparison of some recent sky survey projects are listed in Tab. 1.

PTF was deployed in 2009. The data are processed in IPAC and UC Berkeley according to different scientific interests. The data work flow is summarized in Fig. 1.

The advantages of the PTF project are the dynamical and flexible cadences for various kinds of astronomical objects. Some major interesting topics, such as supernovae, moving objects in solar system, and variable stars, are studied in the collaboration.

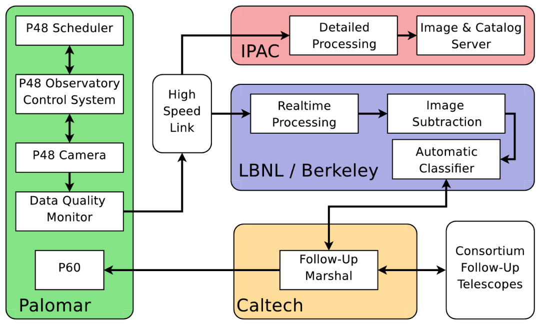

Figure 1. The PTF Data Work Flow (adopted from Law et al. 2009)

2. CATACLYSMIC VARIABLES WITH PTF/IPTF PROJECT

Cataclysmic Variables (CVs) are a kind of close binary, composed of a white dwarf (WD) as primary and possibly a late-type main sequence companion. For most cases, there is an accretion disk surrounding the white dwarf primary. The system is complex, and usually shows different variabilities according to various mechanisms.

Systematic studies of CVs are rare, particularly of their long-term variability. Szkody et al. (2002) studied galactic CVs with SDSS data. However, no long-term variability study was performed. We made use of PTF 4-year data to study the long-term behaviour of the CVs. The catalog by Ronald Downes (1997) was adopted to perform cross-matching with the PTF detection database. 344 CVs are matched in our study; the distribution of the sources are shown in Fig. 2. A num-

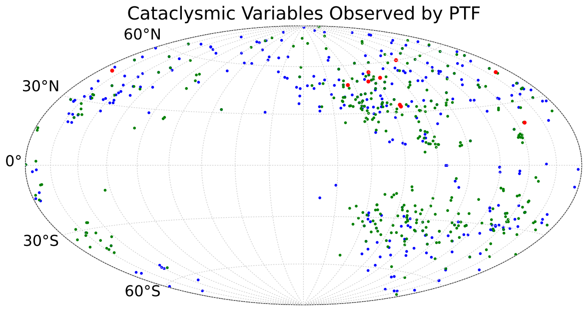

Figure 2. Distribution of the CVs (in galactic coordinates) found in PTF/iPTF Project (blue: matched CV with Downes' catalog; green: new CV found by PTF team (paper in preparation); red: CVs in this study having significant long-term periodicities)

Table 2
Summary of the Long-term Periodicities

Name	Type	$P_{\rm orb}$ (d)	$P_{\rm long}$ (d)
J05581789+6753459	DN	0.149969	265.979
J09193569+5028261	CV	—	247.859
J09201119+3356423	DN/NL	0.07859	42.165
J140820.91+533040.2	Nova	—	74.197
J15321369+3701046	CV	—	59.901
J155037.27+405440.0	CV	—	43.603
J155654.47+210719.0	DN	0.083161	283.617
J160003.9+331115	DN	—	161.439
J17183699+4115511	CV	0.205833	34.875
J172405.7+411402	AM Her	0.083824	235.654

ber of new CVs have been found by the PTF team according to their outburst phenomena, as shown in Fig. 2.

3. PERIOD ANALYSIS AND CRTS DATA

We used the Lomb-Scargle Periodogram (LSP) and Phase Dispersion Minimization (PDM) to determine the long-term periodicity. Folded light curves are plotted with the most probable periods from the power spectra. A visual inspection was made to ensure the variation profile is valid. In addition, we use the Catalina Realtime Transient Survey (CRTS) data as supplement (through CSDR2).

4. LONG-TERM FOLDED LIGHT CURVES OF CVs

There are about 20 − 30 sources found to have long-term periodicities. After neglecting low significance ones, 10 sources are presented in this article. The folded light curve with their best period are shown in Fig. 3. The results are summarized in Tab. 2.

5. POSSIBLE MECHANISMS FOR THE LONG-TERM VARIATIONS

There are various mechanisms to explain the long-term periodic variabilities. Possible ones are:

1. Precession of accretion disk (e.g. Kotze et al., 2012)
2. Magnetic field change of the companion star (e.g. Richman et al., 1994)
3. Hierarchical triple systems (e.g. Chavez et al., 2012)

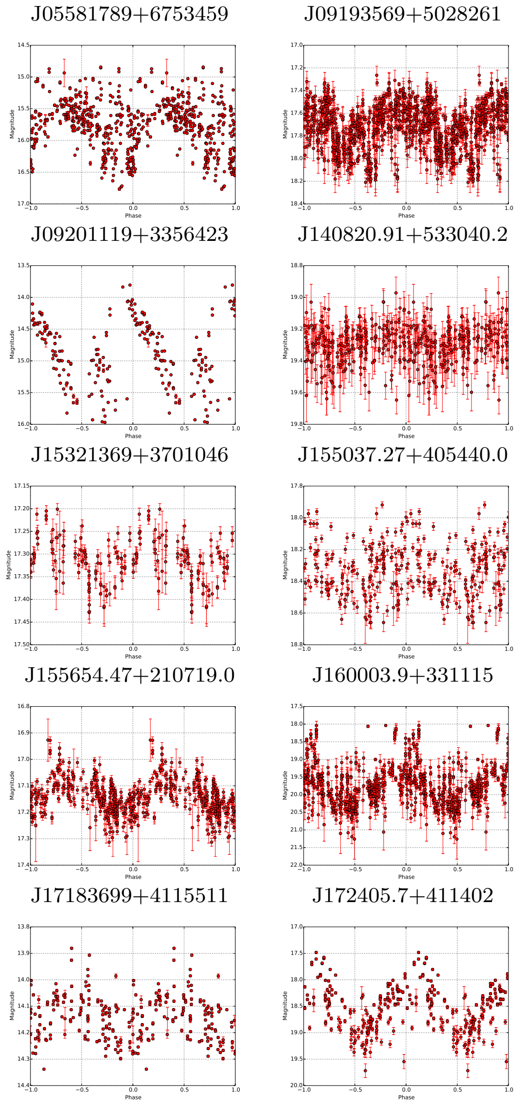

Figure 3. Folded Light Curves of CVs with Best Periods

4. Superoutburst cycle (e.g. Kato et al., 2002)

The $P_{\rm long}$ is unlikely due to disk precession, because the beat period with orbital period exceeds the expected range of superhumps ($(P_{\rm sh} - P_{\rm orb})/P_{\rm orb} > 1 - 7\%$). For other possible mechanisms, we probably need more information (e.g. time resolved spectroscopic or multi-color observations) to distinguish them. There is a new instrument in iPTF collaboration called the SED Machine, which provides a very low resolution spectrum, will help us to study the CVs in more detail.

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