Orbital Period Analyses for the CVs Inside the Period Gap

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OUTLINE

• What is the Period Gap?
• New orbital period distributions of CVs
• Orbital period analyses
• Summary
Part I. Period Gap
What is the Period Gap?

Katysheva & Pavlenko (2003)
Why is there a gap?

**Selection effect for observation**  
(Rappaport et al., 1983)

**CV Evolution**

A. The corresponding gap in white dwarf mass distribution  
(de Kool, 1992)

\[ M_{wd} \leq 0.46 M_\odot \]  
for the CVs below gap

\[ M_{wd} \geq 0.56 M_\odot \]  
for the CVs above gap

B. The similar gap has already been shown in the distribution of progenitors of CVs  
(Vojkhanskaja., 2007)

Progenitors of CVs: White dwarf + red dwarf binary system / PCEBs

C. Disrupted Magnetic Braking hypothesis  
(Robinson et al., 1981; McDermott & E. Taam, 1989)

Sharp reduction in AML rate when secondary becomes fully convective
Standard paradigm of CV evolution

A default argument:
CVs evolution will shorten its Orbital period

Above Gap
Magnetic Wind
With radiation core

Below Gap
Gravitational Radiation
Full Convective

Inside Period Gap
Part II. Investigation
Details of Orbital period distribution

- The distributions for different subtype of CVs
  a) Bimodality caused by DN and NL
  b) The shallower gap in MCV and DN
  c) No gap in NL and N&RN

- The pie diagram for the CVs inside period gap
  a) MCV is a significant subtype inside period gap
  b) The other subtypes are nearly equal and MCV

- The pie diagram for the CVs below period gap
  a) DN becomes a significant subtype below period gap
  b) Over 75% CVs below gap are DN and MCV
• A gradual rise branch near 2hr — is it a result caused by gravitational radiation?

• CVs have spread over the whole gap.

• The real minimum of gap is near 3hr — is it a possible evidence for the sudden decline of stellar wind?

• A small shift towards longer period.

Smaller interval 10mins for histogram of orbital period distribution.
CVs inside gap should be exclusive objects very very very very
Part III. Analyses
## Eclipsing CVs inside gap

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Eclipse CVs</th>
<th>Orbital Period (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCV</strong></td>
<td>*<strong>HU Aqr (~15mag)</strong></td>
<td>0.086820459 (2.08h)</td>
</tr>
<tr>
<td></td>
<td>!DD Cir (~20mag)</td>
<td>0.09746 (2.34h)</td>
</tr>
<tr>
<td></td>
<td>*<strong>UZ For (~18mag)</strong></td>
<td>0.087865446 (2.11h)</td>
</tr>
<tr>
<td></td>
<td>*<strong>V348 Pup (~15mag)</strong></td>
<td>0.101838933 (2.44h)</td>
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<tr>
<td></td>
<td>!V597 Pup (&gt;18mag)</td>
<td>0.119583333 (2.6687h)</td>
</tr>
<tr>
<td><strong>DN</strong></td>
<td>*<strong>DV Uma (~19mag)</strong></td>
<td>0.085852633 (2.06h)</td>
</tr>
<tr>
<td></td>
<td>*<strong>IR Com (~15mag)</strong></td>
<td>0.087038644 (2.09h)</td>
</tr>
<tr>
<td></td>
<td>!SDSS J170213 (~18mag)</td>
<td>0.100082090 (2.40h)</td>
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<tr>
<td></td>
<td>!CTCV J1300-3052 (~16mag)</td>
<td>0.088850000 (2.13h)</td>
</tr>
<tr>
<td></td>
<td>?TY Psa (~14mag)</td>
<td>0.084100000 (2.02h)</td>
</tr>
<tr>
<td></td>
<td>!V Per (~18mag) 1887</td>
<td>0.107123474 (2.57h)</td>
</tr>
<tr>
<td></td>
<td>!DD Cir (~20mag) 1999</td>
<td>0.097460000 (2.34h)</td>
</tr>
<tr>
<td><strong>N &amp; RN</strong></td>
<td>!V630 Sgr (~18mag) 1936</td>
<td>0.118000000 (2.83h)</td>
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<tr>
<td></td>
<td>!QU Vul (~19mag) 1984</td>
<td>0.111764700 (2.68h)</td>
</tr>
<tr>
<td></td>
<td>!V597 Pup (&gt;18mag) 2007</td>
<td>0.119583333 (2.6687h)</td>
</tr>
</tbody>
</table>
Photometries for AM Her

(Dai et al., 2012, in preparation)

It locates at the upper edge of period gap. Its secular evolution state is a key factor to test the current evolution theory.
New O-C diagram of AM Her

A typical period decrease rate $\sim 10^{-10.15}$

Low-state data just add the large scatters
The orbital period variations

Log($P_{\text{mod}}$) = -0.36($\pm$0.10)Log($\Omega$) + 0.018

This increase can be counteracted by the gravitational radiation.

$R_3/a \sim 10^3$

The magnetic braking may be suppressed in polars (Cumming, 2002).

Including Algol, RS CVn, WUMa and CVs (Lanza & Rodonò, 1999)
Decreasing orbital period

(Qian et al., *MNRASL*, 2011)

<table>
<thead>
<tr>
<th></th>
<th>HU Aqr(b)</th>
<th>HU Aqr (c)</th>
</tr>
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<tbody>
<tr>
<td>Amplitude (d)</td>
<td>0.000 107(17)</td>
<td>0.000 122(14)</td>
</tr>
<tr>
<td>Eccentricity</td>
<td>0.0</td>
<td>0.51(±0.15)</td>
</tr>
<tr>
<td>Period (yr)</td>
<td>6.54(±0.01)</td>
<td>11.96(±1.41)</td>
</tr>
<tr>
<td>Distance (au)</td>
<td>3.6(±0.8)</td>
<td>5.4(±0.9)</td>
</tr>
<tr>
<td>Mass (Jup)</td>
<td>5.9(±0.6)</td>
<td>4.5(±0.5)</td>
</tr>
</tbody>
</table>

A planetary system with three giant planets

(Solar Titius-Bode relation)

(Qian et al., *ApJL*, 2008)

\[ R_A^2 \frac{dM_{MB}}{dt} = -2.95 \times 10^{-9} \]

When \( i > 15.7^\circ \)  
\( M_s < 0.072 \) (solar mass)
Can we find the orbital period increase?

\[ \dot{R}_{cr} \propto \frac{\lambda(q)}{q - 1} P_{orb} \]

- Normal CVs cannot sustain conservative mass transfer.

- It obviously conflicts with hypothesis of CV evolution

We need to pay more attention to the increasing O-C diagrams
The more observations in a long baseline are necessary for checking this increasing trend.

Different models can result in totally opposite variation trends.

It should be a substellar object for both models (>90% probability).

Possible increasing orbital period

(Dai et al., in preparation)

(Dai et al., MNRAS, 2010)
The orbital period distribution for different subtype exhibits the complication of gap.

Part of the eclipsing CVs inside gap never give us definite secular evolitional information.

Most of modulations in O-Cs can be explained by light travel-time effect.
Thanks for your attention!

Any Comments?