Type-I Burst as a Probe of the X-ray Binary Corona

Jian Li ¹

On behalf of:
Long Ji², Shu Zhang², Yupeng Chen² & Diego F. Torres¹, Peter Kretschmar³, Maria Chernyakova⁴ et al.

1. Institute of Space Sciences (IEEC-CSIC), Spain
2. Institute of High Energy Physics (CAS), China
3. ESA/ESAC, Spain
4. Dublin City University, Ireland
Outline

1. Introduction

2. The feedback of type-I bursts to the corona
   (1) The case of IGR J17473-2721
   (2) A general sample

3. Conclusions
Introduction

The spectra of Low Mass X-ray binary:

- Soft / Thermal components: neutron star & accretion disk
- Hard/ Comptonized components: Corona or Jet

A corona in a region close to the compact object is usually invoked to account for the hard X-ray emissions but a direct observational evidence is still missing
- **Origin of Corona**
  - Disk evaporation
    - (Meyer et al. 1994)
  - Magnetic re-connections
    - (Zhang et al. 2000)

- **Formation Timescale**
  - ~days
  - ~milliseconds
LH/HS transition:

cooling or reheating of the corona in days

Light curve of IGR J17473-2721

Chen et al. 2012
To decode the corona puzzle one needs the proper probe:

1. intense soft X-rays
2. short time scale

BH XRB: none
NS XRB: the thermal nuclear flare (type-I bursts)
Proper probe: type-I bursts:

Thermal nuclear explosions on the surface of neutron star.

- a sudden increase and an exponential decay, modeled by a blackbody with $T \sim 3\text{keV}$
- Tens to hundreds of seconds

Burst flux
thermonuclear energy

Persistent flux
gravitational energy
The feedback of type-I bursts to the corona -- IGR J17473-2721

Soft and hard X-ray light curve covering the 2008 outburst.

The 2008 outburst experienced a two-months preceding low/hard state (LHS) and a lagging LHS with respect to the high/soft state (HSS)
X-rays light curve 48 s before and 80 s after the flare peak are regarded as the background and are subtracted for each burst in soft and hard X-ray.

After the persistent emission is subtracted off, bursts are combined for those located in the preceding LHS.
The 30–50 keV profile is anti-correlated with 2–10 keV profile under a correlation coefficient of -0.89.

The 30–50 keV X-rays lag the 2–10 keV X-rays by 0.7 ± 0.5 s.
The 30–50 keV profile is anti-correlated with 2–10 keV profile under a correlation coefficient of -0.89.
The hard X-ray shortage is likely from the cooling of corona, but not from the cooling of jet:

1. The hard X-rays in low/hard state of atolls are corona dominated
2. The opening angle of the NS surface respect to jet is too small for effective Compton cooling.
3. The direction of type I burst and jet are both outwards in which effective cooling could not happen.
Dynamical time scales of seconds.

Disk evaporation: days

Magnetic reconnection: seconds or less
The feedback of type-I bursts to the corona
-- A general sample

Is it universal to NS XRBs?

A general sample:
all atoll sources with RXTE observations, burst number > 5

<table>
<thead>
<tr>
<th>Source</th>
<th>Source</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4U 1608-52</td>
<td>IGR J17511-3057</td>
<td>4U 1916-053</td>
</tr>
<tr>
<td>4U 1702-429</td>
<td>SLX 1744-300</td>
<td></td>
</tr>
<tr>
<td>4U 1728-34</td>
<td>SAX J1750.8-2900</td>
<td></td>
</tr>
<tr>
<td>EXO 0748-676</td>
<td>4U 1705-44</td>
<td></td>
</tr>
<tr>
<td>4U 0513-401</td>
<td></td>
<td>4U1636-536</td>
</tr>
<tr>
<td>x1735-444</td>
<td>KS 1731-260</td>
<td></td>
</tr>
<tr>
<td>4U 1820-30</td>
<td>XTE J1759-220</td>
<td></td>
</tr>
<tr>
<td>HETE J1900.1-2455</td>
<td>IGR J17473-2721</td>
<td></td>
</tr>
<tr>
<td>1M 0836-425</td>
<td>Aql X-1</td>
<td></td>
</tr>
<tr>
<td>EXO 1745-248</td>
<td>GS 1826-238</td>
<td></td>
</tr>
</tbody>
</table>

Ji et al. 2014a,b, 2013
Chen et al. 2012, 2013
A tiny life cycle of the corona may serve as the first evidence of directly seeing the rapid disappearance and formation of a corona in an XRB.

The corona cooling during Type I burst is observed in a small sample of atoll sources.