MATCHING THERMONUCLEAR (TYPE-I) BURST OBSERVATIONS WITH MODELS

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Forty years of studying thermonuclear (type-I) bursts from accreting neutron stars have revealed a surprisingly rich spectrum of behavior. A few sources that have been studied intensively offer confirmed examples of several of the classes of ignition predicted theoretically (e.g. [1]), and these systems serve as crucial test-cases for numerical models. Here we describe a systematic attempt to match these test-cases with the results of numerical models.

The sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Bursts</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS 1826–24</td>
<td>mixed H/He (case III)</td>
<td>2</td>
</tr>
<tr>
<td>SAX J1808.4–3658</td>
<td>pure He (case IV)</td>
<td>3</td>
</tr>
<tr>
<td>4U 1820–30</td>
<td>pure He (no H accreted)</td>
<td>4</td>
</tr>
<tr>
<td>4U 1636–536</td>
<td>superburst</td>
<td>5</td>
</tr>
</tbody>
</table>

The bursts

- **4U 1820–303**

- **SAX J1808.4–3658**

- **GS 1826–24**

- **4U 1636–536**

**Burst selection criteria**

We identified sequences of bursts from the target sources observed at high signal-to-noise by the Rossi X-ray Timing Explorer, drawn from the Multi-Instrument Burst Archive (MINBAR; [6]), with the following criteria:

- occurring within episodes of regular recurrence times, with consistent burst profiles; or,
- inferred accretion rate is a good predictor of the recurrence time

These properties imply “ideal” conditions (complete fuel consumption, steady accretion rate) in contrast to the more typical irregular burst behaviour.

The matching approach

This sample will also serve as a set standard cases for numerical ignition models, by which the results of different codes may be compared.

In the future, it is anticipated that such comparisons may lead to constraints on key nuclear reactions important for determining the burst lightcurves and energetics.

What you should do now

If you are working on a numerical model for bursts, get in touch! We can provide preliminary versions of the burst lightcurves along with suggested input parameters.

If you’re in the Tokyo area, come to the “satellite” meeting of the ISSI team next Monday–Wednesday @ RIKEN

If you’re a member of JINA-CEE, get involved in the burst project, listed under MA2 on the wiki

References


Figure 1: Lightcurves for selected bursts in the reference sample. From top to bottom, we show averaged He-bursts from the ultracompact binary 4U 1820–303; He-bursts (occurring after the accreted H is exhausted by steady burning) in the 401-Hz millisecond pulsar SAX (1808.4–3658); averaged mixed H/He bursts in the “testbook” or “clocked” burster, GS 1826–24; and a superburst from 4U 1636–536. The recurrence time, where known, is indicated in each panel. Note the change in y- and x-axis scales between some of the panels. The luminosity is calculated from blackbody fits to the time-resolved 3–20 keV spectra, assuming standard estimates of the distance to each source.

Figure 2: We plan to match the sample bursts (example shown here in blue) with a large set of simulation results (green, from [7]) along with the recurrence time.

Figure 3: Code is under development to perform the matching, identifying the best-fitting model curve, and derive the posterior distributions on the system parameters. Representative distributions for a preliminary single-epoch match, including distance and gravitational redshift are shown here.