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Reconciling observations and models of thermonuclear bursts with nuclear experiments

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Forty years of studying thermonuclear (type-I) bursts from accreting neutron stars have revealed a surprisingly rich spectrum of behaviour. A few sources which have been studied intensively offer confirmed examples of two of the three classes of ignition predicted theoretically, and these systems serve as crucial test-cases for numerical models. Some new classes of bursts have also emerged in recent years, including so-called "super" bursts, likely powered by unstable ignition of carbon, and intermediate-duration bursts which likely require a large accreted reservoir of pure helium. However, the attempts made to date to match observations to numerical models in detail have been limited, due both to the computational cost and the difficulty for modellers to access fully-analysed observational data.

In this talk I will report on efforts to resolve this situation via collaborative teams within JINA-CEE and the International Space Science Institute in Bern, Switzerland. Recently we have completed assembly of a set of representative observations of four key sources, which are intended to be used by modelling teams both as standard cases to quantify model-to-model discrepancies, and also for use to match the observations at different ignition conditions, fuel composition and accretion rates.

In parallel we have been focussing on two approaches for detailed burst-model comparisons, focussing on one of the key sources, SAX J1808.4−3658. We used a burst ignition model to match trains of bursts observed during a transient outburst, updating the results of Galloway et al. (2006, ApJ 652:559). The comparisons allow us to constrain the accreted composition as well as the neutron star mass and radius, with astrophysical implications for the evolution of the system. In parallel, a separate approach focuses on the (much more computationally intensive) KEPLER simulations of the same source, which will also be reported at the meeting.

We anticipate that this project will allow us to quantify in details the typical model uncertainty related to simulations of thermonuclear bursts, and potentially also will reveal important differences between model codes that need to be addressed. Ultimately, establishing burst-model comparisons as a viable method to constrain the rates of individual reactions will offer complementary measurements to nuclear experiment

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