A New Method for Determining the Stability of Material Accreting onto Neutron Stars

Jeremy Heyl and Ramesh Narayan
Harvard-Smithsonian Center for Astrophysics

What was old is new again

- Our technique:

LINEAR
STABILITY
ANALYSIS

In other words…

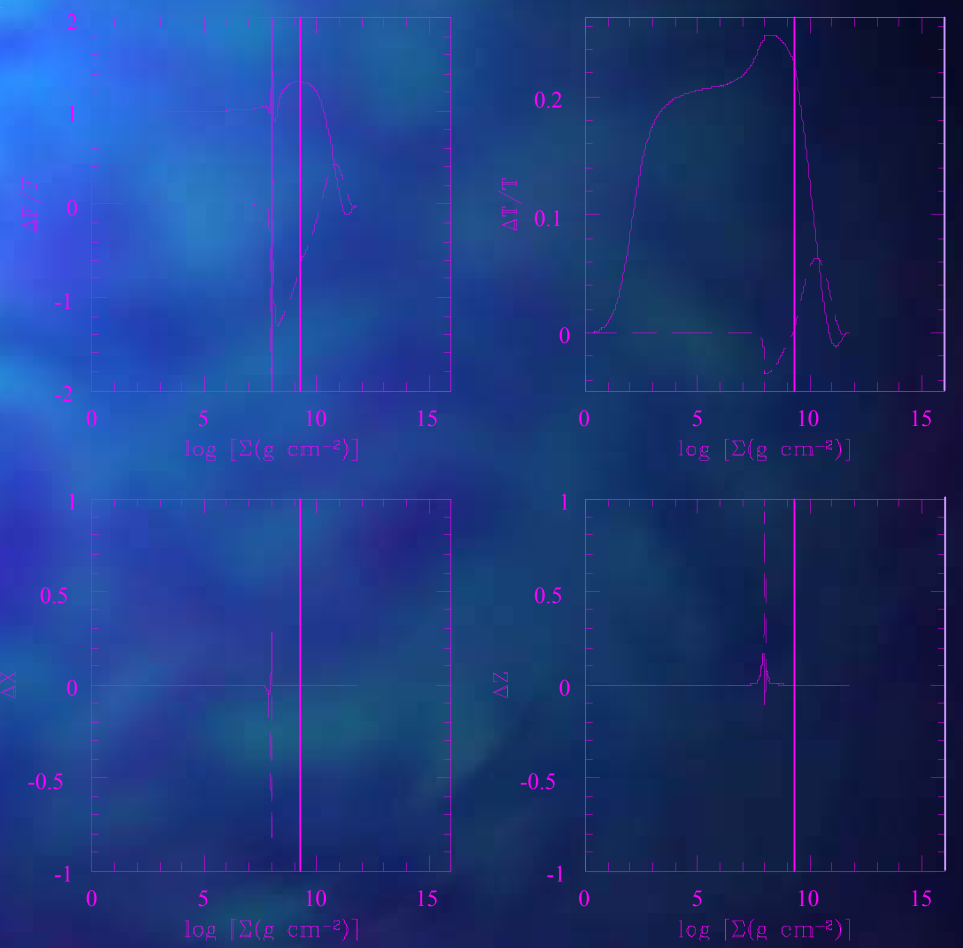
- We, for the first time, calculate both the structure of a steady-state burning layer on a neutron star and the perturbations of that steady-state solution to linear order.

What makes it better?

- For each configuration, we know
  - whether it is stable,
  - what drives the instability,
  - how fast does it grow, and
  - whether the burning oscillates.
- Earlier analyses typically gave a sense about the stability but little else.
- Does the mode grow faster than the accreted layer?

How does it work?

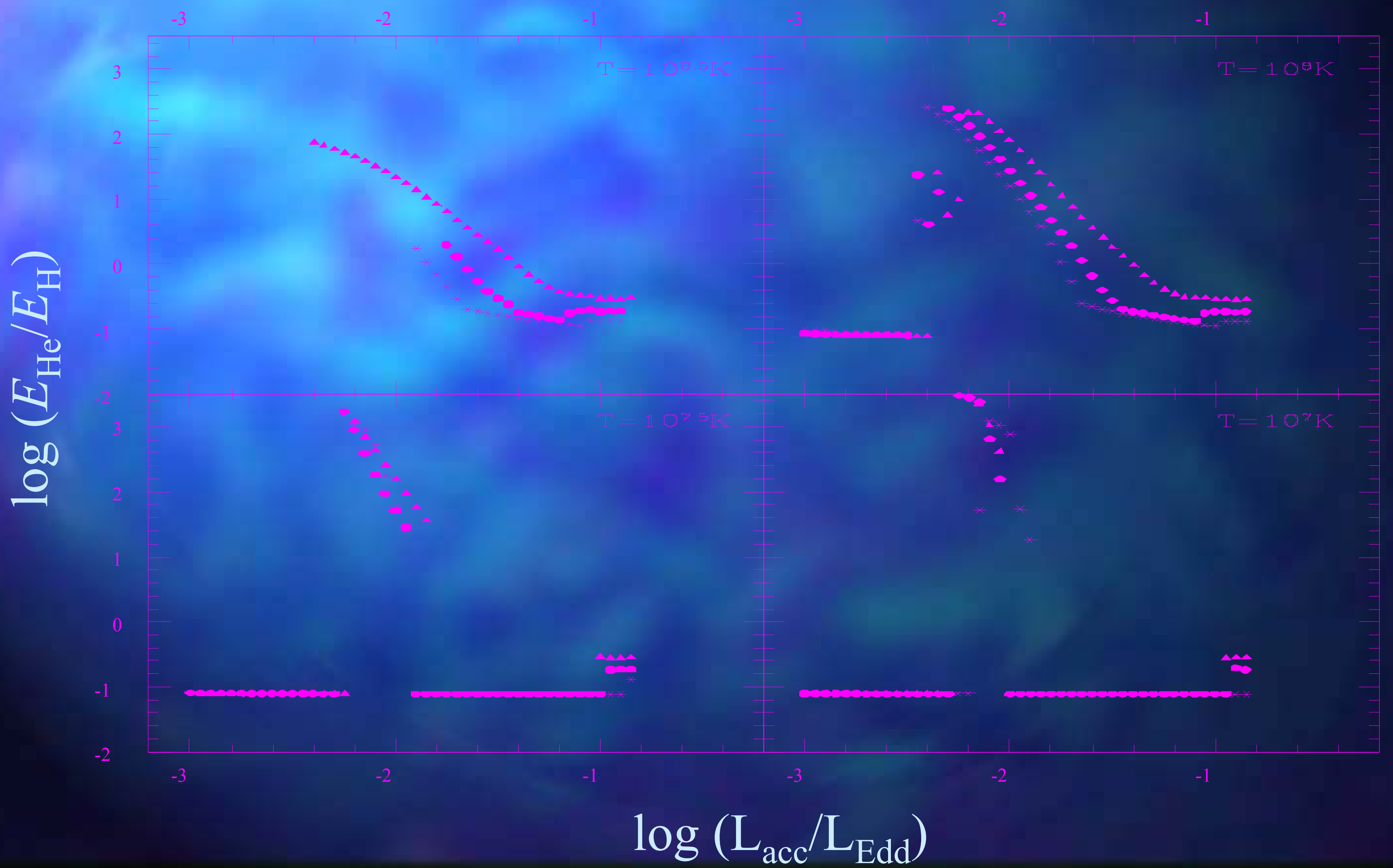
- Perturb the outgoing surface flux,
- Calculate the new solution [with $f_1 e^{\gamma t}$],
- Vary γ until $T_1=0$ at a depth where the diffusion time is $1/|\gamma|$.
- Bonus: $F_1=0$ too



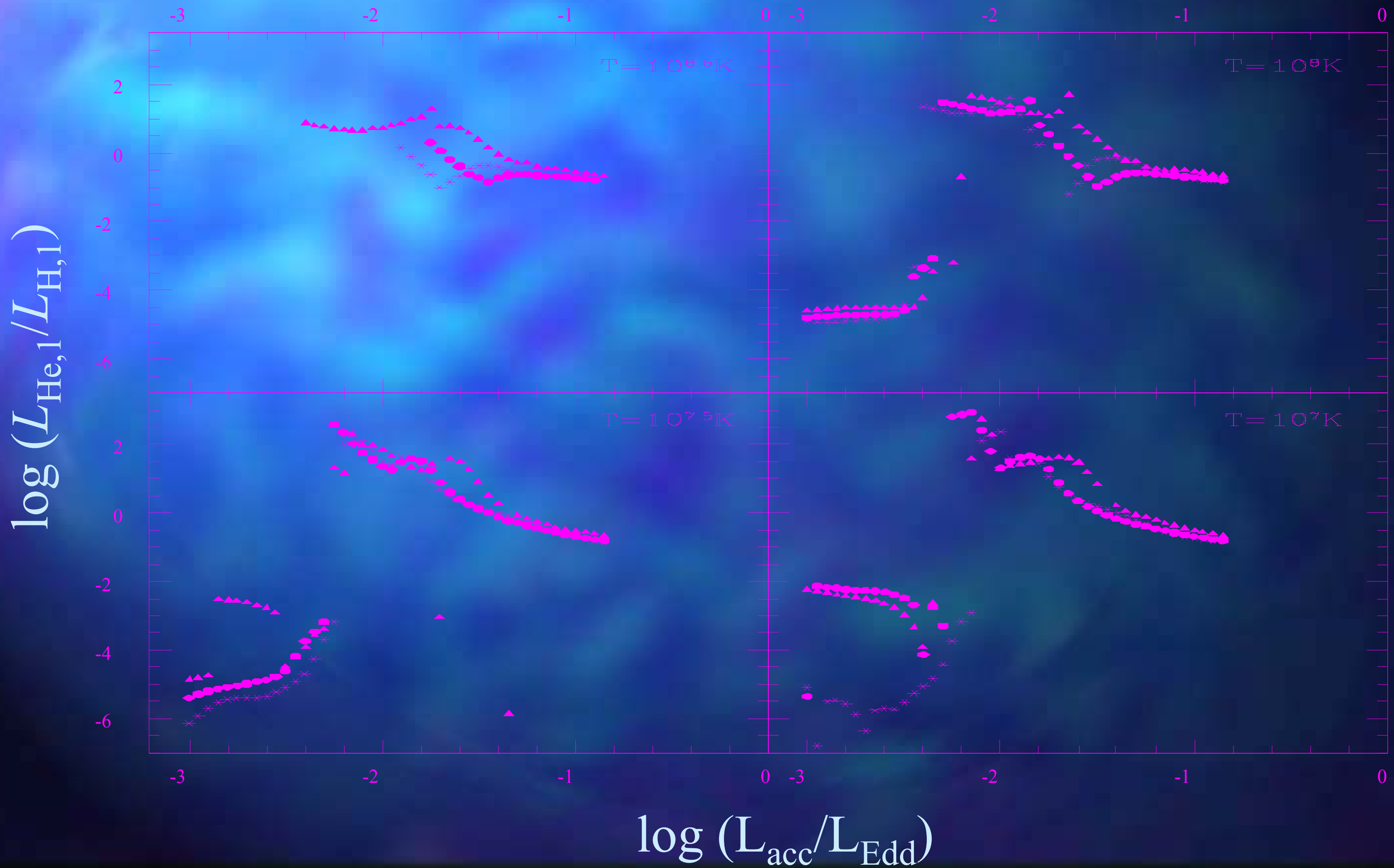
Does it really work?

- We find the same major burst regimes:
  - H bursts
  - He bursts
  - Mixed bursts
- Prompt v. delayed bursts
- Unstable v. overstable triggers

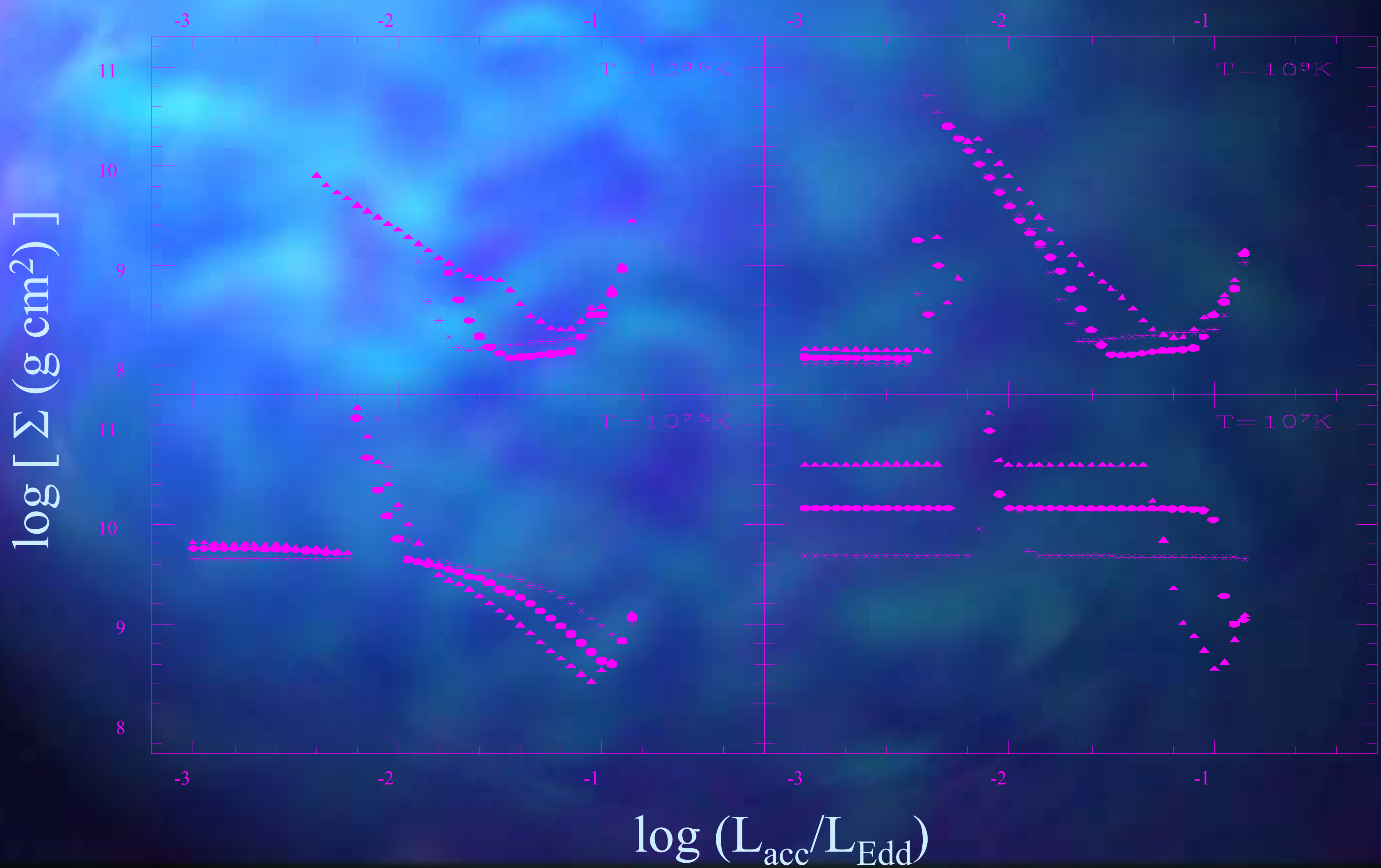
Which type of fuel?



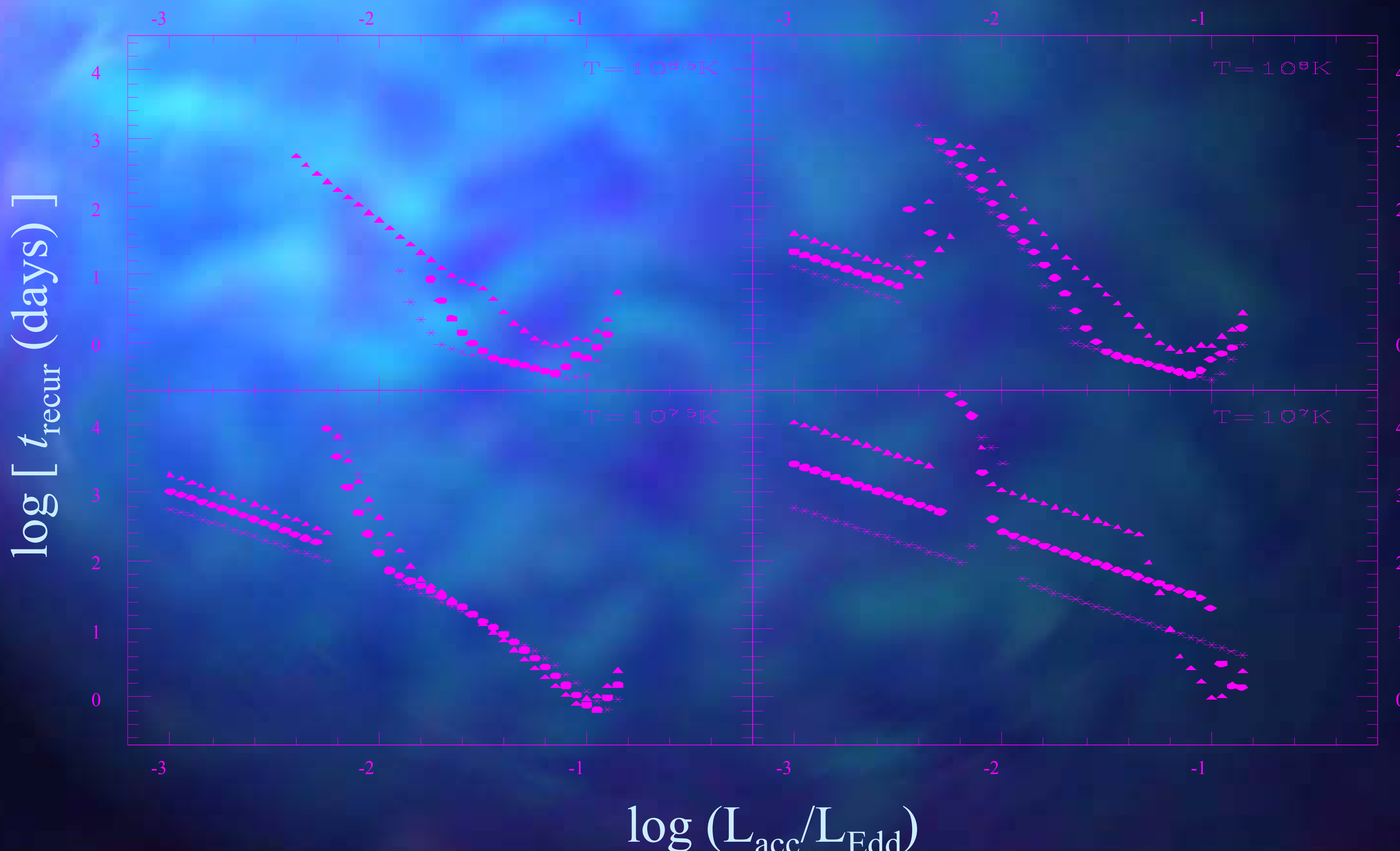
Which type of trigger?



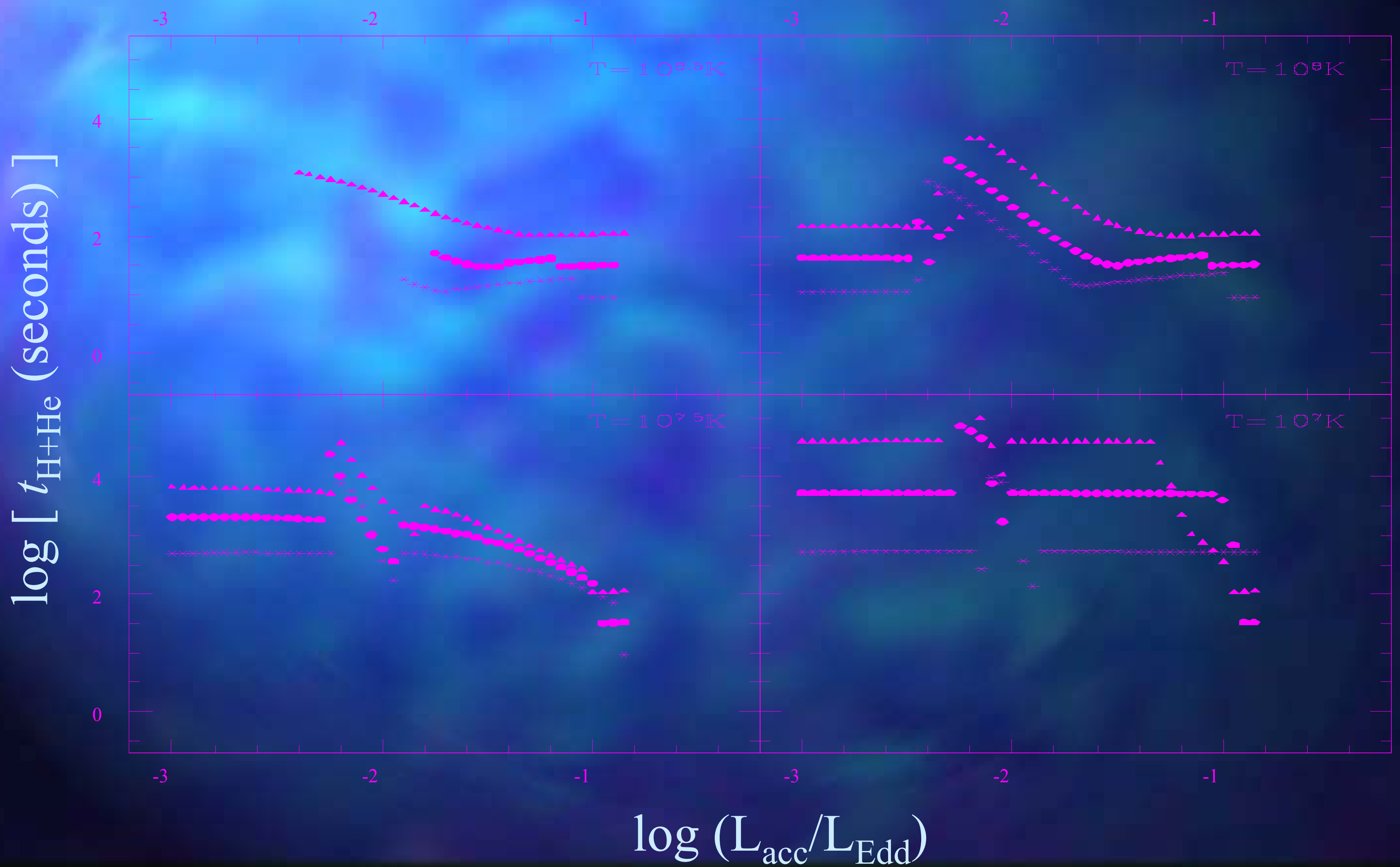
Critical Column Densities



Recurrence Time

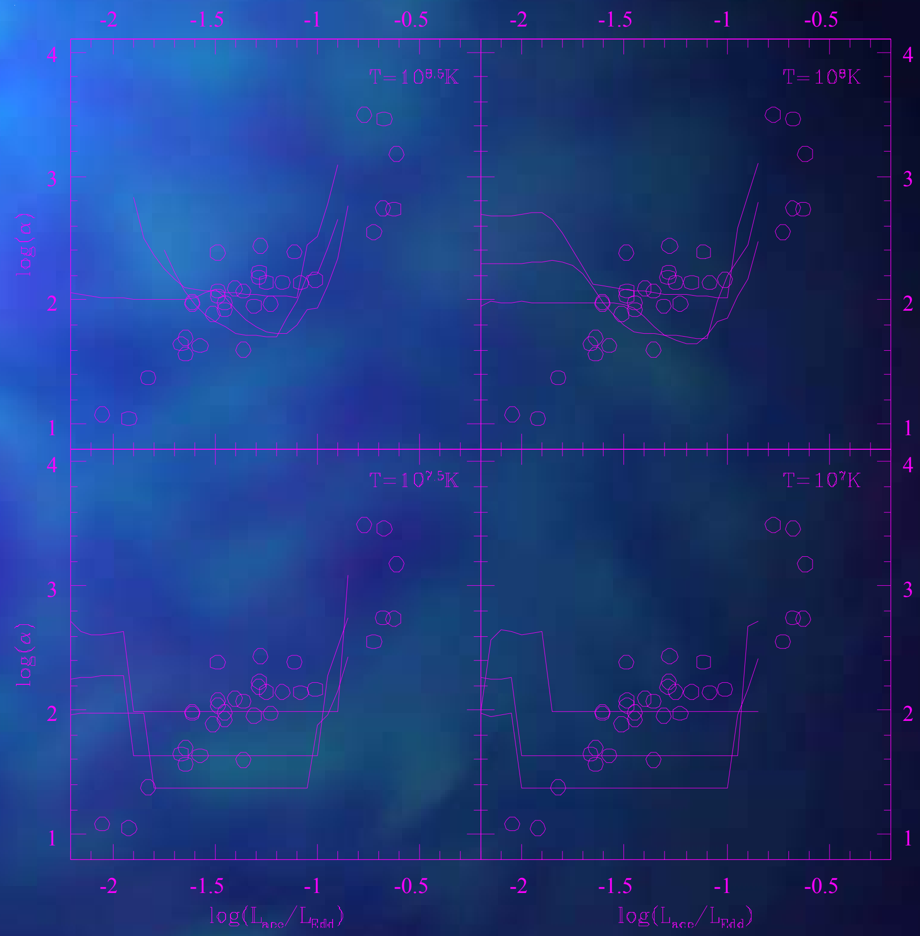


Burst Duration



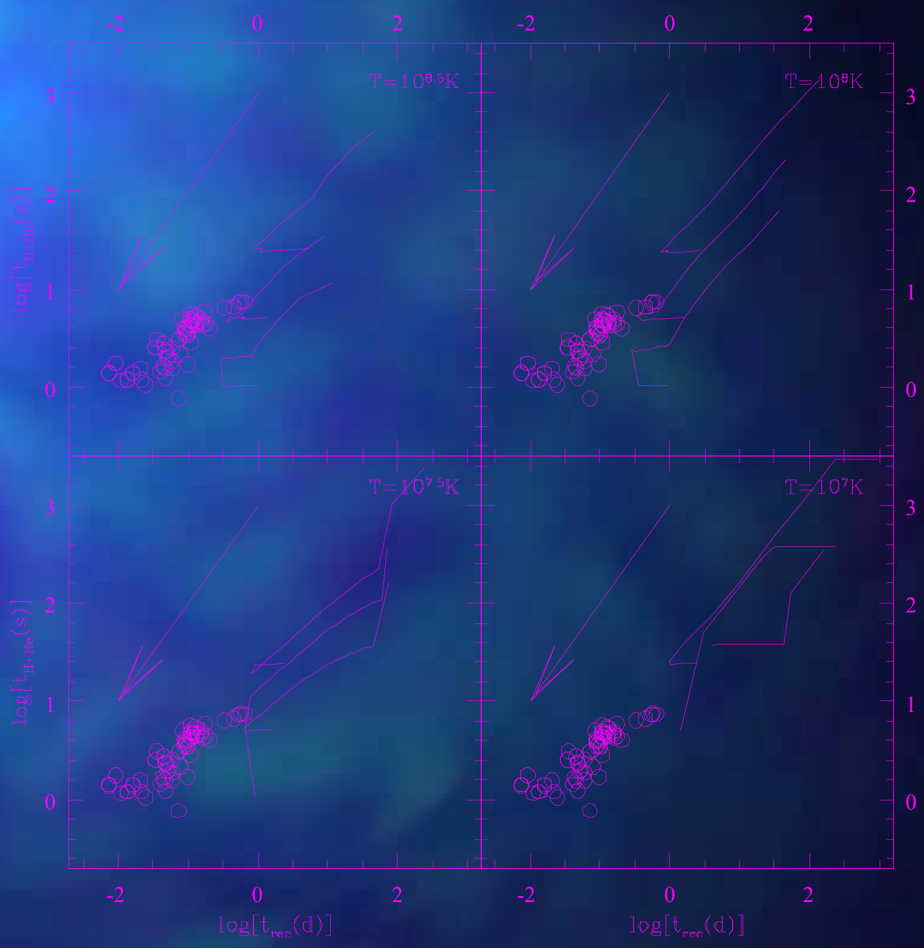
Observational Comparison (α)

- α is the ratio of the persistent flux to the flux during the burst
- Above 3% L_{Edd} we find the same trends in α as observed.
- Below 3% L_{Edd} we can't account for the low values of α.



Duration and Interval

- The bursts that our prescription predicts typically last longer and are less frequent than observed.
- The fuel layer only burns partially, leaving material for the next burst.



Where can I buy one?

- Check out astro-ph/0303447.
- Our method faithfully reproduces all of the previously known burst regimes for hydrogen and helium burning.
- It also identifies a new region of mixed bursts on the onset of stable burning where the burst is delayed and a substantial portion of the fuel is consumed in between bursts.