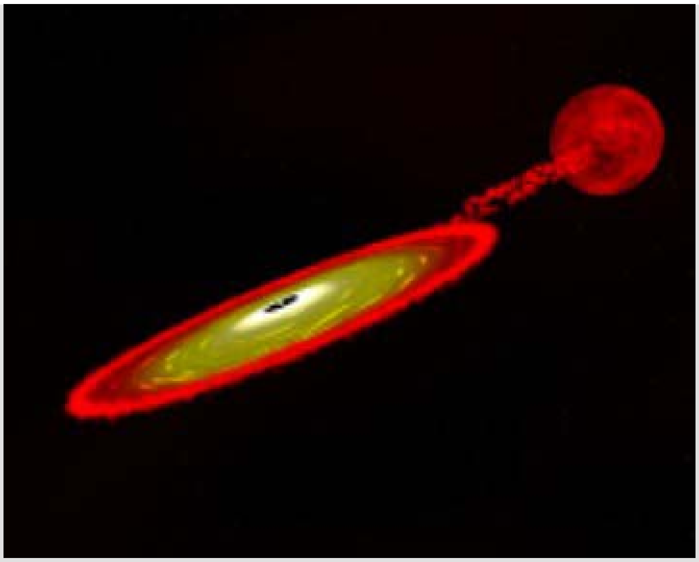
Weak hydrogen-powered explosions on accreting neutron stars



The image at left depicts how an accreting neutron star might look. Hydrogen-rich gas is stripped from a solar-like star at the top right and sprials onto the neutron star (dot in center of disk). The accumulated hydrogen and helium on the neutron star surface eventually becomes unstable to a thermonuclear runaway, which produces a bright burst of X-rays.

Image credit: NASA/HEASARC

Many observed neutron stars accrete gas from a companion star. Once enough gas has piled up on the neutron star surface, nuclear reactions ignite and trigger an explosion known to astronomers as an *X-ray burst* . JINA scientists at the University of Chicago and Michigan State University have proposed that for systems where gas is transferred slowly, the ignition of hydrogen is not violent enough to trigger a strong X-ray burst. Most hydrogen in the universe has a nucleus consisting of a single proton. In order to convert four hydrogen nuclei into a single helium nucleus, two of the protons must be converted into neutrons in what nuclear physicists call a *weak reaction.* As the name suggests, this reaction proceeds slowly and the hydrogen on the surface cannot heat the surface fast enough to keep up with the radiative cooling. As a result, when the hydrogen does begin to fuse, there is only a weak flash, which just burns the accumulated hydrogen to helium.

What happens to this helium layer? As part of her dissertation, University of Chicago graduate student Fang Peng (now a Sherman Fairchild Postdoctoral Scholar at Caltech) proposed that a deep helium layer would accumulate over many of these weak bursts. When this deep helium layer finally ignites, the unstable fusion reactions would create a large energetic flare. This pattern of numerous weak hydrogen flashes followed by a large helium explosion might account for the usually energetic X-ray bursts observed from some slowly accreting neutron stars.

Curiously enough, if the rate at which gas is transferred from the companion were further decreased, the hydrogen layer would become deep enough at

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ignition that it could not cool as easily. In this case the hydrogen fusion would then trigger helium fusion, as had been proposed by Fujimoto et al. and Ayasli and Joss in the early 1980's. Because helium has as many neutrons as protons, the reaction can proceed quickly, and a "normal" X-ray burst ensues.

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