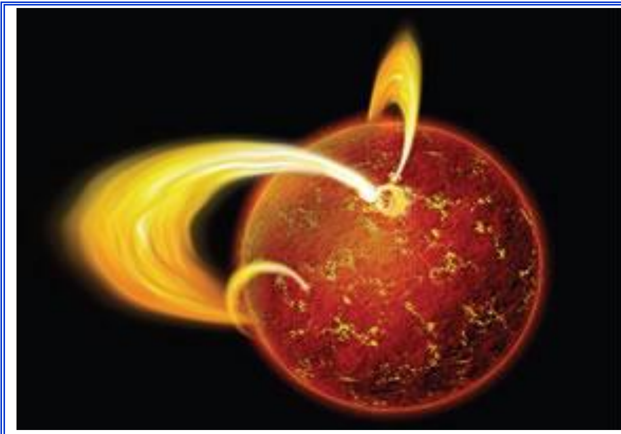
Constraints on Neutron Star Crusts from Oscillations in Giant Flares



Magnetars, highly magnetized neutron stars, undergo starquakes which cause the emission of giant flares of gamma rays.

Credit: NASAFigure

Magnetars are neutron stars which are observed to have large magnetic fields, up to 10^{15} Gauss or more. Magnetars are observed to emit giant flares of high-energy X-rays and gamma rays. The most extreme giant flares emit 10^{46} ergs of energy over a short time scale of only a few minutes. Previously observed giant flares from magnetars have been sufficiently strong to significantly modify the ionization states in the Earth's ionosphere. Giant flares are thought to be generated by "starquakes", seismic events in the neutron star crust analogous to earthquakes.

The giant flares exhibit quasi-periodic oscillations (QPOs), nearly regular modulations of the X-rays. While these QPOs are not well understood, some of them are thought to be normal modes of the neutron star crust. These normal modes are torsional modes, which twist matter around the surface instead of pushing matter against the graviational potential, and the fundamental torsional mode as well as higher harmonics are exhibited as QPOs in a giant flare.

Andrew Steiner (MSU), in collaboration with Anna Watts (Univ. of Amsterdam) constructed a new model of the neutron star crust and paid particular attention to the nuclear symmetry energy, the energy cost of creating a nucleus with a different number of neutrons than protons. Steiner and Watts showed the QPO frequencies are strongly correlated with the nuclear symmetry energy, and thus the QPO frequencies are an important constraint on the properties of nuclear matter. It was also demonstrated that the fundamental torsional mode may have a lower frequency than previously thought.

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