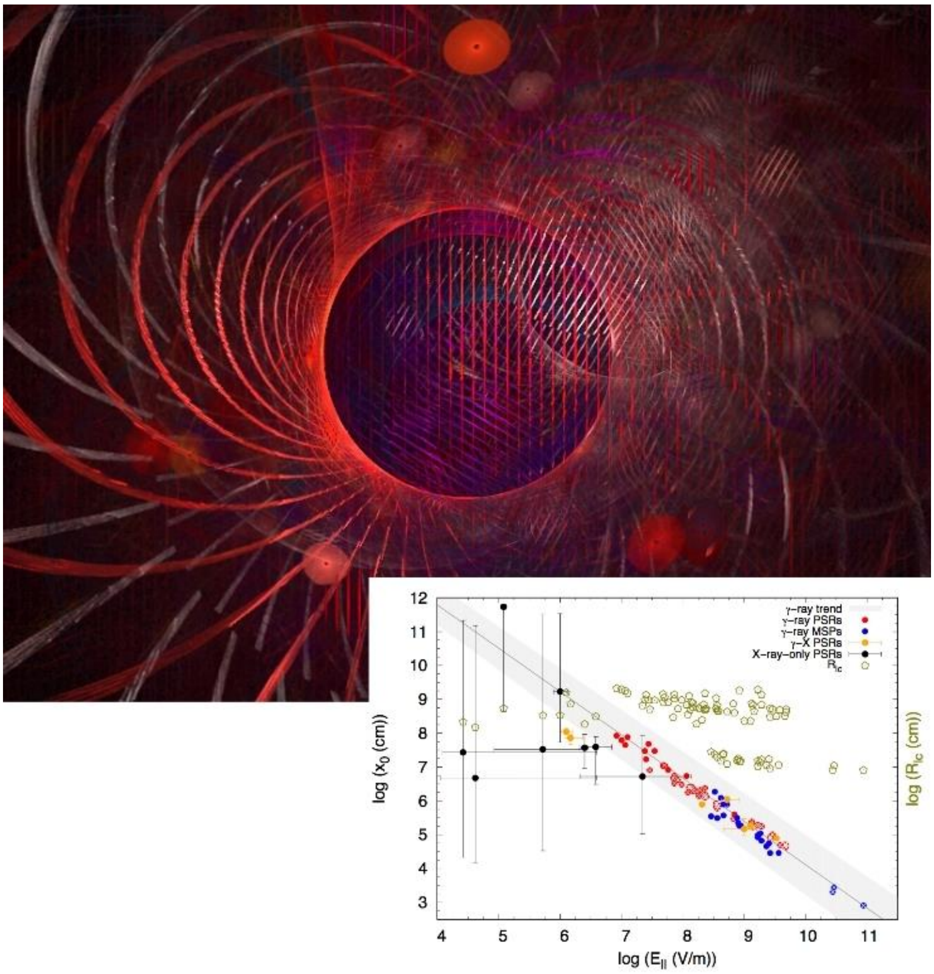
INTEGRAL PICTURE OF THE MONTH
MARCH 2018



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WHICH GAMMA-RAY PULSARS CAN BE SEEN BY INTEGRAL AND WHY?

Neutron stars are a common compact endpoint of the life of stars. They have an extreme density (stars of about 10 km in size, with the mass of our Sun), and harbour the strongest magnetic fields (from 10^8 to 10^{14} times that of our Sun). Magnetized and rotating neutron stars emit beams of radiation, which can only be seen when the observer and the beam are aligned. Periodic recurrence of such alignment gives rise to pulsations, and to the name pulsar used for these objects.

Pulsars emit at all wavelengths, and their energy distribution (that is, how much power they yield at each wavelength band) varies strongly within the population. From the more than 2000 radio pulsars known, and the more than 200 gamma-ray pulsars known, we only know less than 20 of them which pulse in X-rays. The number of those detected in INTEGRAL's energy range is even lower.

What makes a pulsar shine in gamma-rays and/or X-ray energies? Ultimately, how can we predict, which pulsar will be visible to a particular X-ray instrument?

Despite the extreme precision of the observations, and the underlying complexity of the processes involved, recently a theoretical model for the spectra of pulsars has been proposed: just four physical parameters suffice to fit the emission spectrum of all gamma and/or X-ray pulsars known. When analyzing the properties for all pulsars, by grouping of these parameters, relevant correlations appear, explaining the different observational behaviours. As a bonus, the model acts as a tool to predict whether X-ray pulsars can be seen, starting from Fermi gamma-ray data. Detailed analysis of already detected and future gamma-ray pulsars can then lead to predicting whether or not INTEGRAL can detect them too.

Expectations for possible detections are shown in the image at the bottom, in the setting of the correlation of model parameters fitting the high-energy spectra of pulsars. Red and blue dots stand for gamma-ray-only, normal and millisecond pulsars, respectively. They show a strong correlation depicted with a dashed line (the shadowed region represents the 2 sigma uncertainty in this correlation). White (grey) crosses within a red/blue colored point denote a predicted flux of at least 10^{-13} erg cm^{-2} s^{-1} (10^{-14} erg cm^{-2} s^{-1}) at 10 keV. The parameters of the X/gamma-ray and X-ray-only pulsars are shown with orange and black points, respectively, together with their 1 sigma uncertainty. The light cylinder R_{lc} of all pulsars is also noted (green pentagons). Uncertainties in the model parameters are larger (smaller) when only X-ray (both X- and GeV gamma-ray) data are available.

Figure Credits: D.F. Torres, Nature Astronomy (2018), and Diego F. Torres/JWildfire for the artistic pulsar representation.

Reference:

- "Order Parameters for the high-energy spectra of pulsars"
  D.F. Torres,
  Nature Astronomy (2018), doi:10.1038/s41550-018-0384-5