A magnetar-powered X-ray transient as the aftermath of a binary neutron-star merger

With the support by the National Natural Science Foundation of China and other grants, the research team led by Prof. Xue YongQuan (薛永泉) at the Department of Astronomy, University of Science and Technology of China, discovered the first X-ray transient that was powered by a magnetar formed during a binary neutron-star merger, which was published in *Nature* (2019, 568: 198—201).

Neutron stars are composed of almost all neutrons. They have extreme physical properties such as ultra-high density and ultra-strong magnetic field. They are excellent natural laboratories for testing basic physical laws. However, our understanding of their basic properties is still relatively vague, e. g. , can the direct product of a binary neutron-star merger be a neutron star rather than a black hole? It is theoretically predicted that if the pressure increases sharply with the increase of nuclear density, the merger of two neutron stars can produce a massive millisecond neutron star with an extremely strong magnetic field (i. e. , a magnetar; see Figure a) or even a stable neutron star. However, such a magnetar has never been confirmed by observations for many years.

Using a new variability diagnostic method developed by the team, they discovered a new X-ray transient (dubbed XT2) that lasted only about 7 hours in the deepest and most sensitive X-ray survey ever—the 7Ms Chandra Deep Field-South, and then studied in detail its X-ray light curve (see Figure b and d), offset from its host galaxy (see Figure c), event occurrence rate, gamma-ray emission, etc. All the key observational evidence and theoretical analyses demonstrate that XT2 is most likely the first magnetar of this kind. The discovery of XT2 confirms the previous theoretical prediction that the direct product of a binary neutron-star merger can be a massive millisecond magnetar, which strongly constrains the basic physics such as neutron-star equation of state and extreme magnetic field, excludes a number of nuclear-matter models, deepens our understanding of basic neutron-star properties, and points out a new direction for future studies of binary neutron-star mergers and neutron-star properties.

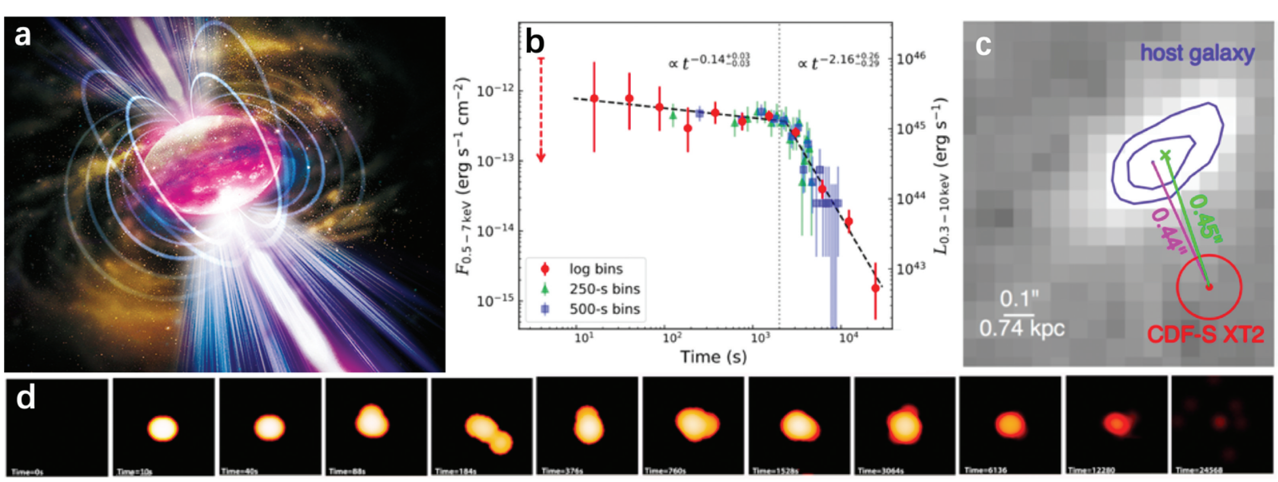

Figure (a) Artist's impression of a magnetar as the aftermath of a binary neutron-star merger (courtesy of Wang GuoYan and He Cong). (b) XT2 X-ray light curve, with the corresponding X-ray images at different time frames shown in (d). (c) XT2 offset to its host-galaxy center.