The Fast and the Furious: extreme stellar flares

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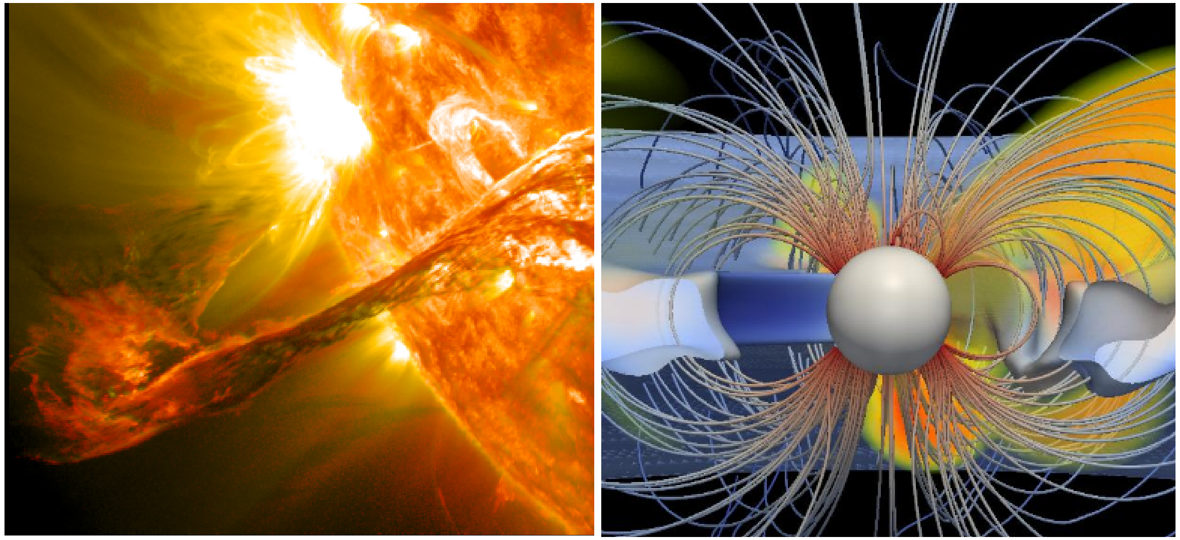
Since the '80s, X-ray images have shown that other stars possess a "corona" like the Sun. The corona is the outer part of the stellar atmosphere, where very hot and ionized gas, called plasma, is shaped by the stellar magnetic field. In such conditions the corona emits a lot of X-rays. For the typical coronal temperatures this emission is largely (> 70%) dominated by a forest of lines whose presence and intensity trace the abundances of major chemical elements and coronal temperatures, respectively.



Left: On August 31, 2012 as a result of a flare a CME erupted out into space with a speed of over 1500 km/s and connected with Earth's magnetosphere, causing aurorae. Credit: NASA. *Right*: 3D MHD (Magneto Hydro Dinamic) simulation of flaring activity occurring close to a circumstellar disk around a rotating magnetized star. The flaring activity gives rise to hot magnetic structures linking the disc to the star and strongly perturbs the disc, whose material evaporates under the effect of the thermal conduction while overpressure waves propagate through the disc.Credit: S. Orlando.

Abrupt and erratic changes of the configuration of the magnetic field produce recurrent reconnection of the field lines and release of energy in form of flares, i.e. very rapid increases of stellar emission that are visible at all wavelengths. In the Sun the flares sometimes are accompanied by the expulsion of a blob of plasma: this phenomenon is a Coronal Mass Ejection (CME). Coronal emission is stronger and hotter among stars more active and/or younger than the Sun. Such active stars often host extreme flares that can release up to 100.000 times more energy than the one of the strongest known solar flares. To date the available evidence of stellar CMEs is very sparse and limited at best. Various pieces of evidence indicate the crucial role of coronal emission (and associated flares) during the early evolution of our protoplanetary system and subsequently on Earth's atmosphere. We have records of some major effect of rather small CMEs on our complex society (e.g. the Carrington event, 1859, the power blackout in North America on 1977).

A*thena*'s sensitive spectrometers will unambiguously determine the presence of a CME contemporaneous with an X-ray flare by tracing the shift of the emission line centroids due to the hundreds km/s velocity of the plasma at the flare onset. This will allow us i) to trace the motions and changes of abundances due to matter evaporating from the stellar chromosphere and/or ii) to find evidence of CMEs and determine their key physical parameters (mass, velocity, energy, etc.). In the case of a young star still accreting matter from its circumstellar disk, *Athena*'s time-resolved spectral study of extreme flares will expose in detail any oscillation of the X-ray emission. This phenomenon has been recently discovered in a few bright flares. With *Athena* we will gain knowledge about the complex interplay of the magnetized corona and the inner circumstellar disk in very young stars, a phenomenon that manifests itself in long lasting powerful flares perturbing the inner disk.