Long term spectral variability in the soft gamma-ray repeater SGR 1900+14

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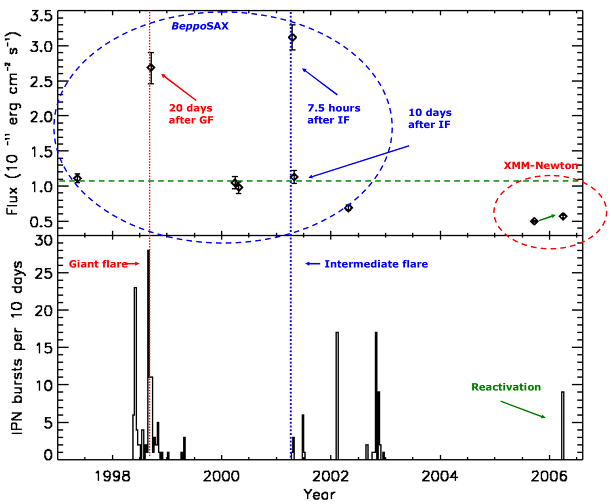
ABSTRACT - We present the analysis of seven *Beppo*SAX and two *XMM-Newton* observations of SGR 1900+14. These observations allowed us to study the long term variability of the source, both in flux and spectral shape. The high statistics of the *XMM-Newton* observations enabled us to perform a sensitive search for spectral features. We also report the detection of hard X-ray (>20 keV) emission in the non imaging PDS instrument aboard *Beppo*SAX. This emission is very likely due to SGR 1900+14 and can be compared with that recently observed with *INTEGRAL*. Finally, in the data collected ~7.5 hours after a particularly bright burst, we explore the possibility of describing the observed short time spectral evolution by means of a cooling thermal component.

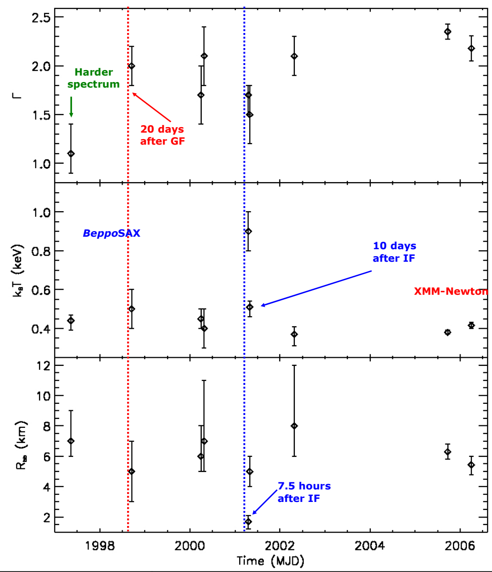
Flux history



During the *Beppo*SAX observations the source was brighter than usual in two occasions: few days after the August 1998 giant flare (fluence ~7×10^{-3} erg/cm^2) and during the 10^5 s long X-ray afterglow following the April 2001 intermediate flare (~3×10^{-4} erg/cm^2). In the last *Beppo*SAX observation the flux was ~25% smaller than in the other quiescent observations and in the first XMM-Newton observation the trend of luminosity decrease was still on going. The second XMM-Newton observation, a target of opportunity obtained after the recent source reactivation (March 2006), shows a ~10% higher flux.

Spectral variability

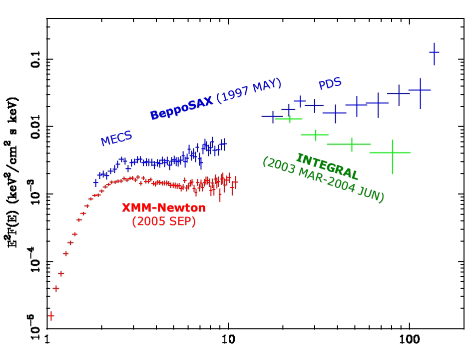
Model: power-law plus blackbody, N_H=2.55×10^{22} cm^{-2} (fixed). The blackbody is required only in 4 *Beppo*SAX observations and in both the XMM-Newton ones. All observations far from strong flares have consistent blackbody parameters: k_BT≈0.4 keV and R_{BB}≈6.5 km (for D=15 kpc). The only observation before the giant flare has a significantly harder spectrum.



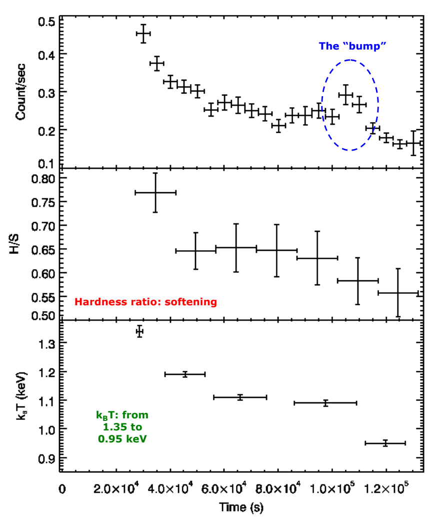
Hard X-ray detections

The field of view of the PDS, the (non imaging) high energy instrument aboard *Beppo*SAX, was clearly contaminated by two pulsars and/or a black hole candidate in all the observations but the first. In that observation we detected a significant persistent emission above 20 keV and, even if we couldn't completely rule out unknown contaminating sources, we fitted the PDS spectrum simultaneously with the MECS. It is consistent both in intensity and shape with the extrapolation of the low energy model.

Götz et al. 2006 reports the *INTEGRAL* detection of a hard X-ray tail of SGR 1900+14. Compared to *INTEGRAL,* the PDS shows a 20-100 keV flux ~4 times larger and a harder spectrum (Γ≈1 versus Γ≈3).

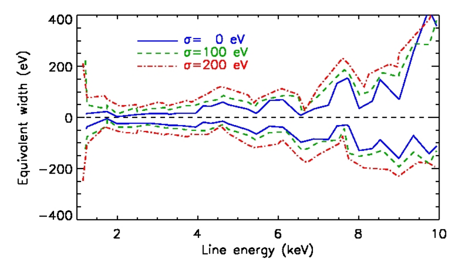


2001 April 18 afterglow



These data, collected ~7.5 hours after the onset of the 2001 April 18 flare, show variations as a function of the time. The flux decrease is well described by a power law with F~ t^{-1} with superimposed a broad "bump" at t≈100 000 s (Feroci et al. 2003). The time resolved spectra are equally well fitted by two models: either a power-law + blackbody with a steady photon index (Γ≈2) and variable k_BT (from 1.3 to 0.7 keV) or the power-law + blackbody model fixed at the quiescent value with an additional blackbody with k_BT decreasing from 1.35 to 0.95 keV.

Search for spectral features



The good statistics provided by *XMM-Newton* allowed us to perform a deep search for spectral features. Cyclotron lines in particular would provide a direct evaluation of the magnetic field intensity. However, no evidence for spectral lines was found. We computed upper limits on the lines equivalent widths as a function of the assumed energy and width. This was done by adding a gaussian component to the model and computing the allowed range in the normalization. The 3σ limits in absorption and in emission are summarized in the figure above.

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INTERPRETATION IN THE MAGNETAR MODEL - The spectral variability observed in the source fits reasonably well in the magnetar scenario, in which the ultimate source of energy for the bursts and the quiescent emission is the decay of the ultra-strong magnetic field (B ~10^{14}-10^{15} G). At intervals, the highly twisted internal magnetic field can twist up the external dipole field and the resulting stresses in the neutron star crust lead to bursts. In this framework a spectral hardening is linked to the increasing torque of the twisted magnetosphere, that finally drives the SGR to a large-scale magnetic reconnection: a giant flare. Then, after the flare, the source is foreseen to relax into a less twisted configuration, with a softer spectrum. In SGR 1900+14, comparing the only pre-giant flare observation with the quiescent post-flare ones, we see a harder spectrum and the hard emission seen with PDS and *INTEGRAL* follows the same trend. The last *BeppoSAX* observation show a significant fainter source and the fading trend was confirmed by the first *XMM-Newton* pointing (~3 years later), suggesting that the source was entering a quiescent phase, like the one observed for SGR 1627-41 (even if SGR 1900+14 was still moderately active during the 2002). The fading phase was interrupted by the recent reactivation, after which the flux increased by ~10%.