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Ten years of XMM-Newton observations of RX J1856.5-3754

N. Sartore[1], S. Mereghetti[1], A. Tiengo[1,2], A. De Luca[1,3], R. Turolla[4,5], and F. Haberl[6]

[1] INAF - Istituto di Astrofisica Spaziale e Fisica Cosmica Milano, Via E. Bassini 15, 20133 Milano, Italy, e-mail: sartore@iasf-milano.inaf.it
[2] IUSS - Istituto Universitario di Studi Superiori, Piazza della Vittoria 15, 27100 Pavia, Italy
[3] INFN - Istituto Nazionale di Fisica Nucleare, sezione di Pavia, via A. Bassi 6, 27100 Pavia, Italy
[4] Dipartimento di Fisica e Astronomia, Università di Padova, via Marzolo 8, 35131, Italy
[5] MSSL, University College London, Hombury St. Mary, Dorking, Surrey, RH5 6NT, UK
[6] MPI für extraterrestrische Physik, Giessenbachstraße, 85748 Garching bei München, Germany

Abstract. We report on the spectral analysis of all the imaging observations of the isolated neutron star RX J1856.5–3754 performed with the XMM-Newton satellite over the last decade. Adopting a single blackbody model, we found variations of the fit parameters of $\sim 1\%$ between different observations, which correlate with the position of the source on the detector and thus are indicative of an instrumental origin. Focusing on a sub-sample of observations, with the source in the same position on the detector, the temperature is compatible with a constant during the period from March 2005 to the present date. A high quality spectrum obtained from this sub-sample is best-fitted with a sum of two blackbodies, with temperatures of $kT_h^\infty = 62.4^{+0.6}_{-0.4}$ eV and $kT_s^\infty = 38.9^{+4.9}_{-2.9}$ eV, with no indication of spectral features. The contribution of the soft blackbody can also account for the flux seen in the optical band.

Key words. stars: neutron – stars: individual: RX J1856.5–3754

1. Introduction

RX J1856.5–3754 (J1856) is the brightest member of the XDINS, a small class of nearby ($d \lesssim 300$ pc), radio quiet, thermally-emitting ($kT^\infty \sim 50 - 100$ eV) isolated neutron stars (e.g. Turolla 2009, for a review).

Among XDINS, only RX J0720.4–3125 has shown large variations of its spectral parameters, whose origin could be ascribed to a glitch event (Hohle et al. 2012). On the other hand, the large amount of data collected for J1856, observed almost twice a year from 2002, allowed us to investigate variations of its spectral parameters over time-scales from months to ~ 10 years, with unprecedent detail.

2. Results

Our analysis focused on the data collected with the EPIC-pn camera (Strüder et al. 2001), se-

Send offprint requests to: N. Sartore

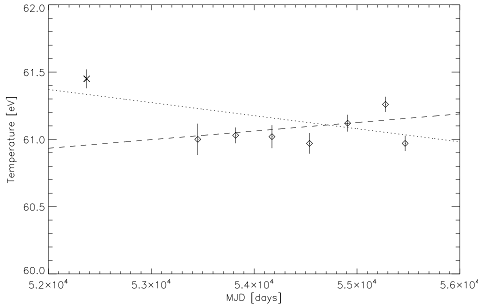

Fig. 1. Long-term evolution of the single BB temperature. The dotted and dashed lines represent the linear fit to the data, with and without considering the observation of April 2002, which is marked by the X symbol. Error bars correspond to 3σ confidence intervals.

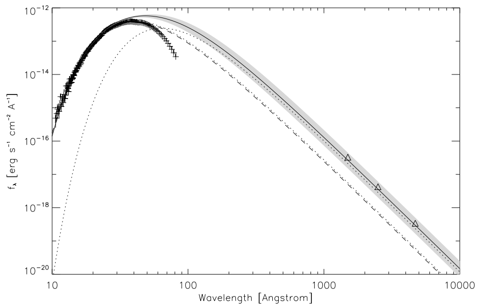

Fig. 2. Broad-band spectrum of J1856. The dashed line is the extrapolation of the (unabsorbed) X-ray BB from Burwitz et al. (2003). The dotted lines indicate the two BB components from Sartore et al. (2012) and the solid line is their sum. The shaded area marks the 1σ confidence region for the best-fit model. The triangles represent the optical/UV data obtained from HST photometry (Kaplan et al. 2011).

lecting photons with energies in the 0.15–1.2 keV range. We observed variations of the order of few percent in the spectral parameters, correlated with the position of the source on the detector and thus likely due to a spatial dependence of the channel-to-energy relation (see Sartore et al. 2012, for details).

Considering only homogeneous observations, i.e. with the source in the same position on the detector, we put strong constraints on the spectral variability of J1856. In particular the blackbody (BB) temperature is compatible with a constant at 2σ level in the period from March 2005 to the present date (Fig. 1). We measured a higher temperature in the April 2002 data which, if not due to alterations of the instrumental response, implies that J1856 is not a steady source, albeit on a smaller scale than RX J0720.4-3125.

We obtained a high quality spectrum (~ 2 million counts) by summing the data from the homogeneous observations. The spectrum is well fit with a two-BB model, the single BB model giving unsatisfactory results. The best-fit BB temperatures are $kT_h^\infty = 62.4^{+0.6}_{-0.4}$ eV and $kT_s^\infty = 38.9^{+4.9}_{-2.9}$ eV, for the hard and soft components respectively. The corresponding BB radii are $R_h^\infty = 4.7^{+0.2}_{-0.3}\,(d/120\,\mathrm{pc})$ km and $R_s^\infty = 11.8^{+5.0}_{-0.4}\,(d/120\,\mathrm{pc})$ km, respectively. With the contribution of the soft BB, the optical/UV flux is increased by a factor of ~ 5 with respect to that of the hard BB alone (Fig. 2), and is broadly consistent with the observed optical/UV flux (Kaplan et al. 2011).

3. Conclusions

Our analysis showed that J1856 is a very stable source, which underwent variations of its spectral parameters not larger than a few percent at most in the last ten years. Thanks to the large amount of homogeneous data we obtained a high quality spectrum which is best-fitted by a two-BB model. We stress however that the parameters of the soft BB are affected by systematic uncertainties because of the not well-constrained energy redistribution below ~ 0.4 keV, and thus have to be taken with caution.

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