A project within the EU-ELTIF framework: a systematic search for (and characterization of) all variable soft X-ray sources at all time scales in the whole archive of observations collected by the European Photon Imaging Camera (EPIC) instrument onboard XMM-Newton since its launch. Phenomenological classification of all detected variable sources will also be performed. All results will be released to the community in a public archive, together with new software tools.

**Rationale**

Variability pervades the cosmos. Almost all source classes detected by high energy telescopes display peculiar variability in flux and/or spectral shape at different time scales, which yields crucial clues on the emission physics.

In the soft X-ray energy range (0.1-12 keV), narrow-field, focusing telescopes have a much larger sensitivity than wide-field monitors and are better suited to spot and study variable phenomena in dim sources. Indeed, a huge amount of time domain information is stored – and mostly unexploited – in data archives.

EPIC is the best available tool to study the variability in the soft X-ray sky:

- composed of a PN (1) and of two MOS (2) cameras at the focus of three co-aligned high-throughput X-ray telescopes
- unprecedented combination of high sensitivity to point sources (>5×10^35 erg cm^-2 s^-1 in 10ks), large field of View (Fov 30' diameter) and good temporal resolution (73 ms and 2.6 s for the PN and MOS cameras, respectively)
- simultaneous coverage of the same field by the three cameras
- launched in 1999 and still fully operative: the long exposure time (>200 million seconds) guarantees a very large sky coverage, yielding the possibility of discovering relatively rare events.

Large efforts are ongoing to explore the serendipitous content of the EPIC database (the XMM Serendipitous Source Catalogue and the XMM Slew Survey), although the time domain remains largely unexplored (see right).

**The context - 1: The EPIC serendipitous source catalogue**

The EPIC serendipitous source catalogue (see e.g. [3]) is the richest X-ray source catalogue ever compiled. It is periodically released by the XMM-Newton Science Center [4], a consortium of ten institutions. It includes all the X-ray sources detected in EPIC observations. A major release of the catalogue, named 3XMM [8], was published in 2013.

Time domain information, 3XMM includes spectra and light curves for sources having more than 100 EPIC counts. Light curves are generated with a nominal time bin yielding at least 20 counts per bin, with a minimum bin time (for bright sources) of 10 s. Only a simple y-test for variability is automatically performed on such light curves and a variability flag is assigned. No systematic investigation of variability is performed by the catalogue team.

**The context - 2: The XMM Slew Survey**

The XMM Slew Survey (XSS) [6,7] is based on data collected while the telescope moves from one target to the next scheduled one.

The XSS is almost as sensible as the ROSAT All-sky Survey (RASS) in the 0.5-2 keV energy range, while it is the most sensitive (near 5×10^-12 erg cm^-2 s^-1) survey in the 2-10 keV energy range.

Time domain information. Comparison of the XSS with the RASS provides the best opportunity to spot extremely rare, highly variable objects and a number of such sources (e.g. Xovol, Total Disruption Events) has been discovered. Thousands of other objects, both identified and unidentified, are seen to have long-term variability, but no dedicated study and cataloguing of such variability has been performed yet.

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**The EXTraS project: work to be done and output**

1. blind search for transient sources

2. systematic search for serendipitous variability

A search down to the 10^-5 time scale, for each EPIC camera (and their combination) in different energy ranges. All detected transients will be studied down to the instrument time resolution.

- discovery of a potentially large number of sources that rose above detection threshold for just a small fraction of the whole observation duration, easily missed, buried in the background, by the standard source detection implemented in 3XMM
- identification of highly variable sources already included in 3XMM but with no time characterization (because of the small number of counts) or with inadequate characterization (because of uncertain time binning).

- a search on much shorter time scales than those allowed by the automatic rebinning of time series implemented in 3XMM, encompassing about 200,000 sources in 3XMM, taking advantage of unbinned photon time of arrival information stored in event files.

- a detailed characterization of the time series properties will be performed for the first time, with a systematic and consistent analysis in order to allow for a phenomenological classification of the sources.

- a search down to P≈0.2, applying state-of-the-art art timing techniques to unbinned photon times for about 200,000 sources in 3XMM. This will be the first systematic search for periodicity ever performed on the EPIC database.

A search on time scales as long as 10 yr on 3XMM and XSS sources, taking advantage of the large number of overlapping observations as well as of the large fraction of the sky visited by multiple slews. Upper limit computations (in case of no detection) will be integrated in the algorithm.

A phenomenological classification, based on consistent, automatic characterization of temporal and spectral variability of X-ray source catalogues, is well under way. The multiwavelength information available in existing catalogues and databases.

- a variable source catalogue, including all detected variable sources and spanning more than 8 orders of magnitude in variability time scale and 6 orders of magnitude in flux.

- Time series, spectra as well as classification and classification results will be released in the catalogue using VO-compliant data models and software.

- Particular effort will be devoted to Quality Control, with a systematic screening and validation of results.

- New software tools will also be made available to the community.

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**The discovery space of EXTraS**

**EXTraS in short**

**The context**

**The context**

Variability

Serendipity

The EXTraS project: Exploring the Transient and variable X-ray Sky

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**References**

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