PROCEEDINGS OF SCIENCE

First catalogue of optically variable sources observed by OMC onboard INTEGRAL

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The Optical Monitoring Camera (OMC) onboard the high energy observatory INTEGRAL provides photometry in the Johnson V band of the same targets observed by the gamma-ray instruments. In addition, OMC monitorizes serendipitously around 100 potentially variable sources within each field of view. At this moment, the OMC database contains light curves for more than 60 000 sources (with more than 50 photometric points each). In this poster we present the first catalogue of optically variable sources observed by OMC, with more than 5000 sources, for which we have studied the optical variability and have derived accurate periods when possible. All data used for this study are publicly available at *http://sdc.cab.inta-csic.es/omc/index.jsp*.

8th INTEGRAL Workshop "The Restless Gamma-ray Universe" - Integral2010,
September 27-30, 2010
Dublin Ireland

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1. Introduction

The INTEGRAL Optical Monitoring Camera, OMC [8], observes the optical emission from the prime targets of the gamma ray instruments on-board the ESA mission INTEGRAL: SPI (gamma ray spectrometer) and IBIS (gamma ray imager), with the support of the JEM-X monitor in the X-ray domain. OMC has the same field of view (FOV) as the fully coded FOV of JEM-X, and it is co-aligned with the central part of the larger fields of view of IBIS and SPI. This combination provides invaluable diagnostic information on the nature and the physics of the sources over a broad wavelength range. In addition, OMC has the capability to monitor serendipitously around 100 sources within its field of view. These targets are all already known targets which are listed in the OMC Input Catalogue [4], wich contains most gamma and X-ray known sources, as well as variable objects of any kind (stars, galaxies, AGN), and HIPPARCOS and Tycho reference stars for astrometric and photometric calibration.
OMC provides photometry in the Johnson V band (centred at 5500 Å) and it is able to monitor sources from V $\simeq$ 7 mag (for brighter sources saturation effects appear) to V $\simeq$ 16-17 mag (magnitude limit for 3σ source detection). Typical observations are done performing a sequence of different integration times, allowing for photometric uncertainties below 0.1 magnitude for objects with V $\leq$ 16.
After the propietary period of one year, all INTEGRAL data are open to the scientific community. At the moment, INTEGRAL has been in orbit for more than eight years and the OMC database (*http://sdc.cab.inta-csic.es/omc/index.jsp*) [7] contains now light curves for more than 60 000 sources (with more than 50 photometric points each). In this contribution we present the "First OMC Catalogue of Optically Variable Sources" which will be released in early 2011.

2. Data Analysis

2.1 Selection of the sources

Sources with more than 300 photometric points have been selected from the OMC database, in order to deal with light curves with enough points to study their variability and when possible, the periodicity. In order to include only high-quality data some selection criteria have been applied to individual photometric points, rejecting those ones that present saturation, low signal to noise or are affected by cosmic rays. After this filtering, we selected 6681 sources.

2.2 Detection of variability

We have fitted a constant to the data in the light curve (supposing the source is not variable). Then we calculate the χ^2 and the significance α. This value gives the probability of being wrong when rejecting the null hypothesis (the source is constant). We have considered as variable those sources with $\alpha < 0.05$ (probability of being variable of 95%). In this way, we have identified 5653 variable sources, which constitute our present Catalogue.

2.3 Study of the periodicity

To determine which sources are periodic and to derive their periods, an algorithm based on PDM (Phase Dispersion Minimization) technique [9] has been developed. This method divides the time-folded data into a series of bins and computes the variance of the amplitude within each bin with respect to a mean curve. This mean curve is obtained by linear interpolations between the means of the bins. The ratio between the sum of the bin variances and the overall variance of the data set is called Θ, and the period that minimizes this value will be the best estimation (see figure 1). After this process, a visual inspection of each folded light curve was performed to identify and correct potential problems (multiple minima in binaries,...).

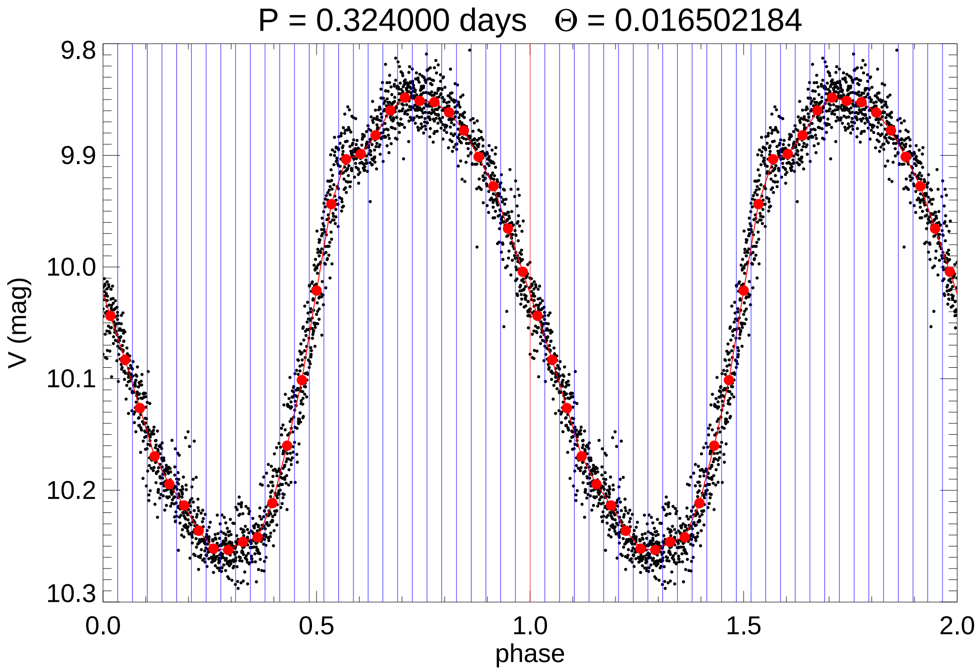

Figure 1: Description of the method developed to derive the period. This example is a light curve folded with the period found for IOMC 0237000032. Black points are photometric observed points and the red ones correspond to the mean curve that has been calculated.

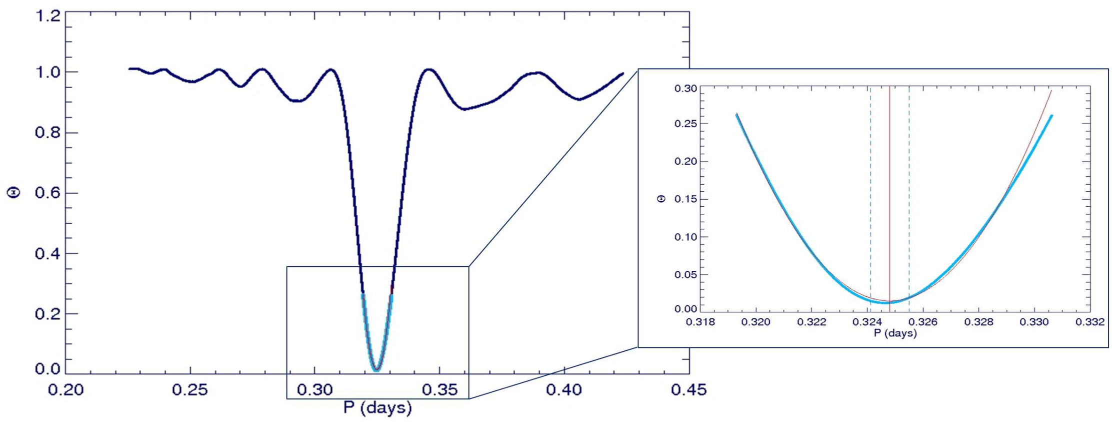

Figure 2: Periodogram of IOMC 0237000032 and detail of the parabolic fit in the peak of the minima used to determine the error on the estimated period.

To calculate the error of the period, we have fitted a parabola to the peak of the periodogram corresponding to the minima. We have estimated the error as the distance from x-value at minima to the x-value corresponding to a height in Θ equal to the deviation of the fit (see figure 2).

The typical values of the periods derived vary between a few hours and 10 days with a peak of frequency in 15 hours (see figure 3). We want to stress that while periods of approximately one day are difficult to measure from ground based observations, due to the day-night window, the 3-days orbital period of INTEGRAL, coupled with the long integration times required by the high energy sources, favours a complete sampling of these relatively short light curves.

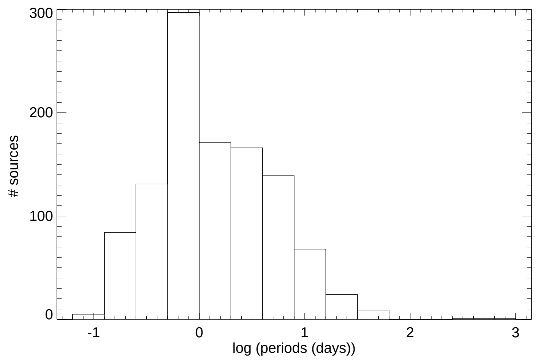

Figure 3: Histogram of the periods derived.

3. Some results

In previous works, light curves of some interesting objects were studied [5], optical counterparts of X-ray sources were identified [3], [1] and some eclipsing binaries were analyzed [10], [11].

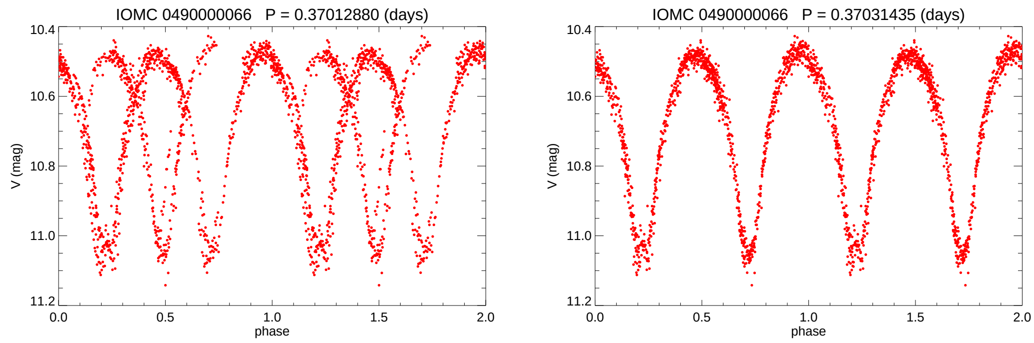

Figure 4: IOMC 0490000066 (V417 Aql). This is a W Ursa Majoris type eclipsing binary. Left: OMC light curve folded with the period from the literature. Right: OMC light curve folded with the period from this work.

In this work, a global study of the sources in the OMC archive has been done. We have determined good periods for approximately 1100 sources, out of the 5635 variable objects compiled in the catalogue. We have obtained good periods for several objects whose periodicity was unknown,

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and in many other cases, we have improved the results with respect to those found in the literature (see figure 4). Some representative examples of the kind of objetcs that can be found in the catalogue are shown in figure 5, where we have plotted their light curves folded with the periods we have derived.

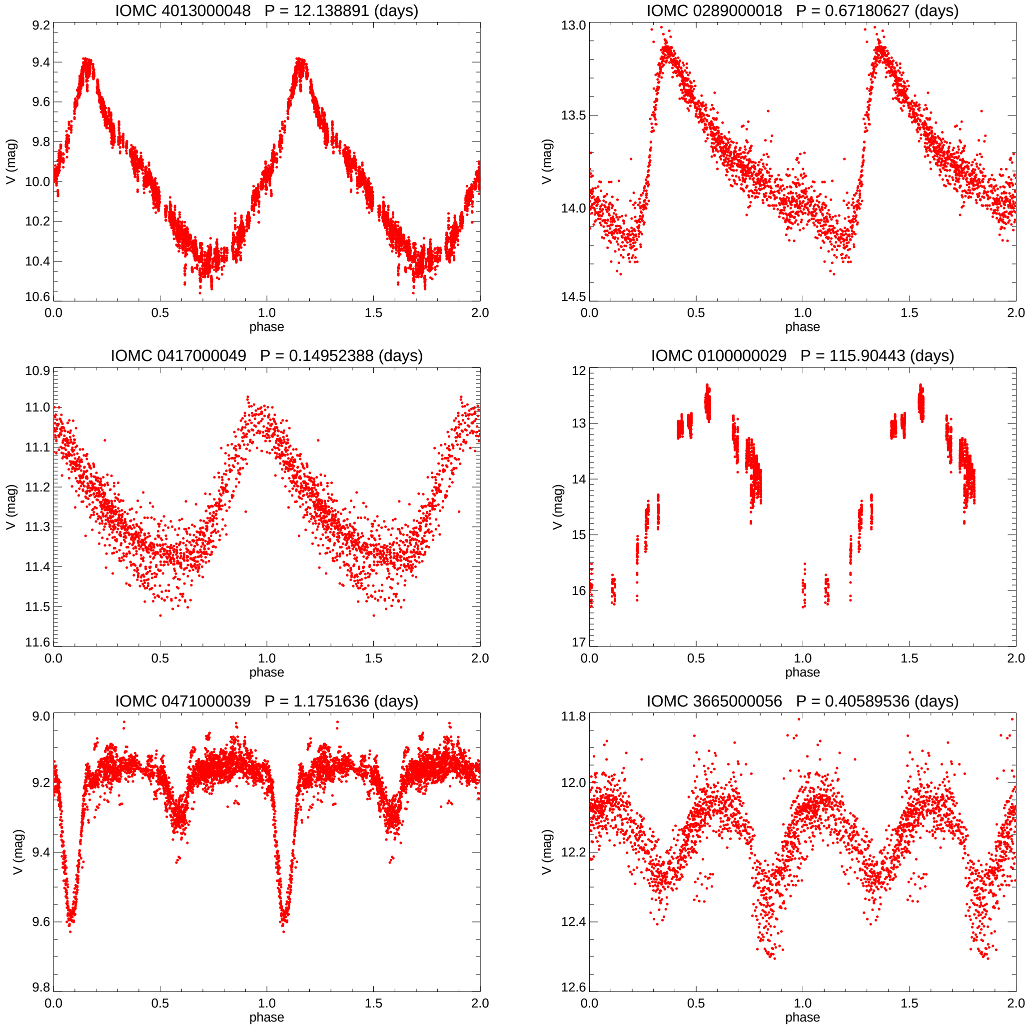

Figure 5: Up: IOMC 4013000048 (AAVSO 2347+58) is a classic Cepheid (left); IOMC 0289000018 (FASTT 520) is a pulsating star of RRAB type (right). Center: IOMC 0417000049 (V567 Oph) is a A6-F1 star classified as Delta Scuti (left); IOMC 0100000029 (FN Ori) is a pulsating star of Mira type (right). Down: IOMC 0471000039 (V1426 Aql) is an Algol eclipsing binary (left); IOMC 3665000056 (BH Cas) is an eclipsing binary of W UMa type (right).

4. Future work

In this first catalogue of optically variable sources observed by OMC, variability information is provided for 5653 sources and periods have been computed for approximately 1100 sources. At the end of the INTEGRAL mission, the final catalogue of optically variable sources will be

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released.
A more detailed study of some of the most interesting sources is being performed, including the cross-correlation with the fourth IBIS/ISGRI soft gamma-ray survey catalogue [2]. Preliminary results can be found in [6].

5. Acknowledgments

This project is being funded by Spanish Plan Nacional de I+D+i (MICINN AYA 2008-03467/ESP).

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