A&A 411, L281–L289 (2003)
DOI: 10.1051/0004-6361:20031400

Astronomy & Astrophysics

Letter to the Editor

The Input Catalogue for the OMC camera onboard INTEGRAL

A. Domingo[1], M. D. Caballero[1], F. Figueras[2,3], C. Jordi[2,3], J. Torra[2,3], J. M. Mas-Hesse[1,4], A. Giménez[1,5], V. Hudcova[6], and R. Hudec[6]

[1] Laboratorio de Astrofísica Espacial y Física Fundamental (LAEFF-INTA), PO Box 50727, 28080 Madrid, Spain
[2] Departament d'Astronomia i Meteorologia, Universitat de Barcelona, Av. Diagonal 647, 08028 Barcelona, Spain
[3] IEEC (Institut d'Estudis Espacials de Catalunya), Edif. Nexus-104, Gran Capità 2-4, 08034 Barcelona, Spain
[4] Centro de Astrobiología (CSIC-INTA), PO Box 50727, 28080 Madrid, Spain
[5] Research and Scientific Support Department, ESA, ESTEC, Postbus 299, 2200 AG Noordwijk, The Netherlands
[6] Astronomical Institute Academy of Sciences of the Czech Republic, 25165 Ondrejov, Czech Republic

Received 10 July 2003 / Accepted 11 September 2003

Abstract. The Optical Monitoring Camera (OMC) onboard INTEGRAL (launched on October 17, 2002) has been designed to obtain *V*-Johnson photometry simultaneously with high energy observations at X-ray (3–35 keV) and gamma-ray (15 keV–10 MeV) performed by the main instruments onboard INTEGRAL. Due to technical limitations on the data processing electronics and the available telemetry, it is necessary to know, a priori, the objects to be monitored within the field of view (FOV) of the OMC. The OMC Input Catalogue – and subsequent updates – provides this information: astrometric and photometric reference stars for calibration and scientific targets for accurate photometric variability studies.

Key words. catalogs – stars: variables: general – galaxies: general – techniques: photometric – astrometry

1. Introduction

The OMC has been designed to monitor in the optical band the high-energy sources observed by the main INTEGRAL instruments. Together with JEM-X, the hard X-ray monitor, they will offer multi-wavelength information of the INTEGRAL targets which is very important to give clues on the nature of the high-energy sources. These simultaneous multi-wavelength observations are particularly important in high-energy astrophysics, where variability is typically fast.

To provide calibrated standard *V*-Johnson photometry for the targets of interest, it is necessary to observe a set of well calibrated photometric reference stars. In addition, the observation of some astrometric reference stars allows the pointing of the camera to one pixel accuracy. Telemetry constraints (only ≈2.2 kbps) do not allow to download the entire OMC image. For this reason, windows are selected around the proposed gamma-ray targets as well as other targets of interest in the same field of view. These additional targets are automatically selected from the OMC Input Catalogue by a specific OMC Pointing Software (OMCPS) running at the INTEGRAL Science Operation Centre (ISOC). Only windows of the CCD containing those objects are transmitted to ground. The OMC Input Catalogue was designed to provide the requested information, the reference stars and the objects of scientific interest. This catalogue will be updated according to the INTEGRAL observations and other ground-based information.

In this paper we describe the compilation of the catalogue giving details of the selection of astrometric and photometric reference stars and the criteria for the inclusion of scientific targets. A section is also devoted to describe briefly the associated OMCPS which creates the commands required to operate the OMC using this catalogue.

In the next section we summarize the OMC scientific performances. A full description of the OMC instrument and its operational modes is given in Mas-Hesse et al. (2003).

2. OMC scientific performances

The OMC consists of an optical system focused onto a large format CCD detector working in frame transfer mode. The optical system is based on a refractive system with entrance pupil of 50 mm, focal length of 154 mm, and a field of view of $5° \times 5°$. The filter assembly holds two colored filters defining a *V* filter (passband centered at 550 nm). The optical throughput of the system is slightly higher than 70%, and the CCD quantum efficiency is around 88%. The Point Spread Function (PSF) has a Full Width at Half Maximum $FWHM \approx 1.4$ pixels.

The CCD (1024×2048 pixels) uses one section (1024×1024 pixels) for imaging and the other for frame transfer before readout. The frame transfer time of around 0.2 ms avoids the need for a mechanical shutter.

Send offprint requests to: A. Domingo,
e-mail: albert@laeff.esa.es

The photometric performance of the instrument is largely limited by its large pixel angular size (17''.504×17''.504), which implies significant contributions from faint stars and zodiacal light. At the 3σ level, the limiting magnitude of the OMC is $V \approx 18$ (by combining 50 images of 100 s each), depending on the background level. For a typical INTEGRAL pointing, the OMC is able to achieve an accuracy of 0.006 mag for objects of $V = 12$, 0.026 mag for objects of $V = 14$, and 0.17 mag for objects of $V = 16$. The photometric accuracy achievable on scientific targets will depend strongly on the crowding of the field.

3. Contents of the OMC Input Catalogue

The current version of the OMC Input Catalogue has been compiled from various sources and contains over 500 000 entries, namely:

- astrometric and photometric reference stars;
- known optical counterparts of gamma-ray sources;
- known optical counterparts of X-ray sources;
- point-like X-ray sources detected and catalogued by ROSAT;
- quasars observable by the OMC;
- known additional AGNs;
- known variable stars (including eruptive variable stars, novae and cataclysmic stars) and
- variable objects which may require an additional optical monitoring.

The astrometric and photometric reference stars have been selected from the *Hipparcos and Tycho Catalogues* (ESA 1997) (hereafter Hipparcos and Tycho-1, respectively). Catalogue descriptions are given by Perryman et al. (1997) and Høg et al. (1997). Because the Tycho-2 catalogue (Høg et al. 2000) provides higher quality data than Tycho-1, astrometric and photometric data have been taken from Tycho-2. Moreover, since the limiting magnitude for Tycho-2 is about 2 mag fainter than for Tycho-1, we have used Tycho-2 data to cope with the problem of contamination by close companions in photometric reference stars. Variability information from Tycho-1 has been also used to build the OMC Input Catalogue.

The OMC scientific mode operations are performed by uploading a table with the expected coordinates of the targets of interest to be monitored by OMC. To arrange this table, a priority flag must be assigned to all scientific targets included in the OMC Input Catalogue. For the assignation of such priority flag, we have adopted as a general criterion:

- priority 1: gamma-ray sources;
- priority 2: bright X-ray sources;
- priority 3: optical variable sources with $V < 18.0$ or without any magnitude;
- priority 4: faint X-ray sources.

4. Astrometric reference stars

The first shot of each pointing of the OMC is devoted to observe a set of astrometric reference stars (typically ten), allowing the pointing of the camera to one pixel accuracy. The result of the centering algorithm is used in the following shots during this pointing.

When the satellite moves from a pointing to another, the pointing is achieved with an accuracy which depends on the slew angle. To find the offset from the planned pointing, the centering algorithm (Mas-Hesse 1999) considers the pixel with the higher number of counts as the one containing the astrometric reference star.

The size of the search window handled by the centering algorithm is 31×31 pixels. This box is large enough for closed loop slews, but it can be smaller than the pointing error for the Galactic Plane Survey operations and for large displacements. To deal with this large pointing inaccuracy, when no solution is achieved by the centering algorithm in the 31×31 pixels box, a spiral search is started. This routine searches in 31×31 pixels boxes, which are moved in steps of 25 pixels around the predicted pointing coordinates until convergence is achieved or the search window has been shifted by more than 100 pixels.

The criteria for selecting the astrometric reference stars are in agreement with the way the centering algorithm works and take into account the size of the search window, the variability of the stars, the proximity among stars and the level of saturation. The most unfavourable case has been always considered.

4.1. Selection criteria

1. **Brightness**
   To ensure that a given astrometric reference star matches the brightest pixel in each possible configuration of the search window handled by the centering algorithm, isolating circles with a radius of $31\sqrt{2}$ pixels centered in each astrometric reference star are used. Each one of these isolating circles must contain only one astrometric reference star. In addition, the following three cases are taken into account:
   - *The selected star is at the edge of a pixel*: The astrometric reference star could be placed at the corner of one pixel. On the contrary, another star in the search window could be well centered in one pixel. Taking into account the OMC point spread function (PSF) ($FWHM \approx 1.4$ pixels) when a star is centered in a pixel, that pixel contains 36% of the total energy. If the star is placed at the corner of a pixel, each one of the four adjacent pixels contains 21% of the total energy. So, the astrometric reference star must be 0.6 mag brighter than all other stars within the isolating box ($\Delta m = -2.5 \log(21/36) = 0.59$).
   - *There is contamination by close groups of stars*: The possibility that some non-reference stars, filling in one pixel, become brighter than an astrometric reference star in the same isolating circle has been also considered. To ensure the above criterion, we imposed that the joint magnitude of a group of stars filling in one pixel must be always 0.6 mag fainter than the magnitude of the reference star; if that is not the case, the reference star is rejected.

– *The completeness limit of the catalogue used*: To ensure the fulfillment of the above conditions, the astrometric reference stars must have $V \leq V_{\rm comp} - 0.6$, being $V_{\rm comp}$ the magnitude completeness limit of the catalogue from which the astrometric reference stars were selected.

2. **Variability**
The stars within the search window can be variable, either the astrometric reference star itself, or the neighbour stars, or both. So, within the isolating box, the astrometric reference star at its minimum brightness ($V_{\rm min}$) must be 0.6 mag brighter than all other stars at their maximum brigthness ($V_{\rm max}$).

3. **Saturation**
According to the CCD performances (Mas-Hesse et al. 2003), the full well capacity is at 120 000 e^{-} pixel^{-1}. As the integration time of the centering shot is ten seconds, the saturation is reached at $V_{\rm satur} \approx 6.3$ mag. However, stars bright enough to reach the full well capacity of a pixel are still accepted as reference stars, provided that blooming[1] does not occur.

   – *Assumption*: To be conservative, blooming is assumed to happen when the number of counts is 1.5 times the full well capacity, so the astrometric reference star must not be as bright as $V = V_{\rm satur} - 0.44$ ($\Delta m = -2.5 \log (1.5) = -0.44$), i.e. $V = 5.9$. According to the OMC PSF, this assumption also ensures that the adjacent pixels will not be saturated. On the other hand, criterion 1 ensures that all other stars within the isolating box will not yield saturation since $V > V_{\rm satur}$, and thus, there will not be two saturated stars within the same search window and no confusion is possible.

   – *Accounting for close companions*: Fluxes of two neighbour stars with separation smaller than the diagonal of the pixel $\cong$ 24.8 arcsec may fall into the same pixel, increasing the possibility of saturation. However, criterion 1 ensures that a minimum difference of 0.6 mag exists, thus giving a decrease of 0.49 mag in the joint magnitude as a maximum. In this case, the bright star may be only as bright as $V = V_{\rm satur} - 0.44 + 0.49$. In the general case, $V > V_{\rm satur} - 0.44 + 2.5 \log(1 + 10^{0.4(V - V_{\rm c})})$ being $V_{\rm c}$ the magnitude of the companion. To account for variability, this reasoning is applied to the star at its maximum brightness: $V_{\rm max} > V_{\rm satur} - 0.44 + 2.5 \log(1 + 10^{0.4(V_{\rm max} - V_{\rm c})})$.

Stars with close companions that do not produce saturation are considered good astrometric reference stars. These close companions should not introduce a critical distortion on the centering algorithm results.

4.2. Selection from the Tycho-1 catalogue

Astrometric reference stars were selected from the Tycho-1 catalogue updating their data with the Tycho-2 catalogue.

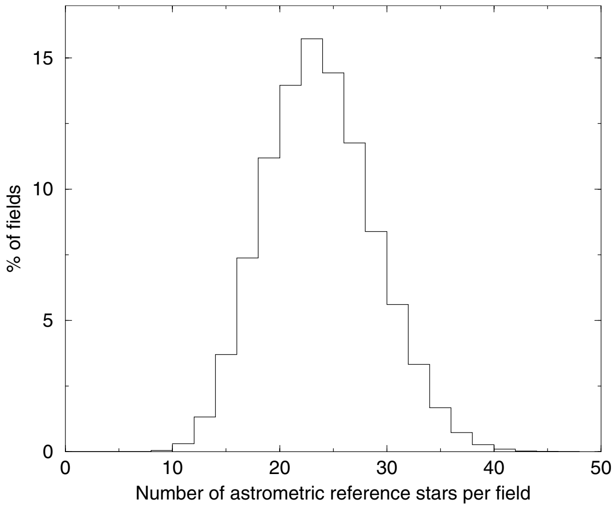

Fig. 1. Percentage of pointings as a function of the number of astrometric reference stars inside a circle of radius 2.°26.

The completeness magnitude of the Tycho-1 catalogue is $V_{\rm T_{comp}} \approx 10.5$. Allowing for a colour $(B_{\rm T} - V_{\rm T}) \sim 2$, we consider, in a conservative case, that $V_{\rm comp} \approx 10.3$ mag[2]. According to the above criteria 1 and 3, only those stars with $V_{\rm min} \leq V_{\rm comp} - 0.6 = 9.7$ mag and $V_{\rm max} > V_{\rm satur} - 0.44 = 5.86$ mag are candidates to be astrometric reference stars.

Those stars with close companions that may produce saturation were not retained. Stars quoted as *dubious astrometric reference star* in the Tycho-1 catalogue were rejected. Those with dubious V-Johnson magnitude and/or no complete information on $V_{\rm T}$ or $B_{\rm T}$ were also rejected.

The final compilation of astrometric reference stars from the Tycho-1 catalogue is composed by 62 721 stars with $5.86 \leq V \leq 9.7$ and always 0.6 mag brighter than all the neighbour stars in a circle of radius $31\sqrt{2}$ OMC pixels (centered on the reference star).

4.3. Number of reference stars per pointing

The centering algorithm will search for a maximum of ten astrometric reference stars (default value) within the OMC FOV. To avoid the borders of the chip and since the centering algorithm will search at a maximum distance from the predicted position of 30 arcmin, only those astrometric reference stars placed within a $4° \times 4°$ box centered in the planned OMC pointing will be selected by the OMCPS.

Figure 1 shows the percentage of pointings as a function of the number of astrometric reference stars inside a circle of radius 2.°26 (the same area as the $4° \times 4°$ box). Table 1 lists the percentage of pointings with less than 10 and 5 as well as 0 astrometric reference stars.

5. Photometric reference stars

After the shot devoted to centering, a shot for measuring a set of photometric reference stars (typically ten) is performed.

[1] Blooming is the result of the overexposure of a star with a CCD camera. The excess illumination causes spill into the adjacent pixels of the transfer row of the CCD device.

[2] Standard relations (ESA 1997) have been applied to transform $B_{\rm T}$ and $V_{\rm T}$ Tycho magnitudes to B and V Johnson magnitudes.

Table 1. Percentage of pointings in the All Sky and Galactic Plane Survey (GPS) with n astrometric reference stars.

n	% pointings (All Sky)	% pointings (GPS)
<10	0.06	0.002
<5	0.00	0.000
=0	0.00	0.000

The goal of this set of photometric reference stars is to provide standard V-Johnson magnitudes of the targets of interest within the FOV (high energy sources, X-ray sources, optically variable sources, etc).

The criteria to accept a star with known V magnitude as photometric reference star for the mission are related with the variability, the multiplicity, the saturation limit of the CCD and the PSF. The most unfavourable case has been always considered.

5.1. Selection criteria

1. **Variability**
   The photometric reference star must not be optically variable.
   Stars with $B-V<0.0$ and those with $B-V>1.3$ were not selected as photometric reference stars because they are likely variable.
2. **Saturation limit**
   As the centering shot, the photometric shot has a duration of ten seconds, giving $V_{\rm satur}\approx 6.3$ mag. The photometric reference star filling only one pixel must not reach this magnitude of saturation ($V>V_{\rm satur}$).
3. **Multiplicity**
   When OMC data are processed at the INTEGRAL Science Data Centre (Courvoisier et al. 2003), a photometric value is obtained for each source by applying an extraction mask of 3×3 or 5×5 pixels. To avoid contamination by other sources present in the extraction mask, the stars with another entry in Tycho-2, at a distance closer than 75″, were rejected as photometric reference stars.

5.2. Selection from the Hipparcos catalogue

Selection criteria based on Hipparcos and Tycho-2 data have been applied to all Hipparcos stars. Those stars in the Hipparcos catalogue with a *coarse variability flag* or with a *flag variability type* (duplicity induced variability, possible microvariable, periodic variable, unsolved variable, revised colour index, ...), as well as stars which appear at *The Hipparcos Catalogue Double and Multiple Systems Annex* (ESA 1997), *Components of Double and Multiple Stars* (Dommanget & Nys 1994) (hereafter CCDM), were rejected as photometric reference stars for the OMC. Those multiple systems with an acceleration, orbital, variability-induced movers (VIM) or stochastic solution were also rejected as photometric reference stars.

In order to ensure absence of multiplicity and variability, we also took into account two recent catalogues, namely *The Tycho double star catalogue* (Fabricius et al. 2002) and *Variable stars in the Tycho photometric observations* (Piquard et al. 2001). These catalogues are reviews of Tycho observations in order to extract new multiple systems and variable stars.

With the previous criteria, 59 892 stars were selected: 10 604 stars having V magnitudes from ground observations and 49 288 stars having V magnitudes transformed from Tycho-2, covering the range $6.3<V<11.49$.

5.3. Selection from the Tycho-1 catalogue

Going to faint magnitudes, we selected all Tycho-1 stars not included in the Hipparcos catalogue in order to apply selection criteria based on characteristics of Tycho-1 and Tycho-2.

In the selection of photometric reference stars we rejected all stars with clear, weak or suspected indication of duplicity. Stars belonging to CCDM and in Fabricius et al. (2002) catalogue have not been retained. All those belonging to *The Combined General Catalogue of Variable Stars, 4.1 Ed.* (Kholopov et al. 1998) (hereafter GCVS) and in Piquard et al. (2001) catalogue have been also rejected.

With the above criteria, 187 804 stars were selected from the Tycho-1 catalogue, 51 209 having $V\geq 10.4$ mag.

5.4. Faint reference stars

Photometric reference stars selected from the Hipparcos, the Tycho-1 and the Tycho-2 catalogues are brighter than typical OMC targets. The stars belonging to the list of Landolt (1992) are used to check the transformation equations from instrumental to standard V-Johnson system, at faint magnitudes.

The faint photometric reference stars of Landolt are located around the celestial equator (75% of the stars have $|\delta|\leq 1°$ and 99% of the stars have $|\delta|\leq 15°$). The list contains 526 stars mainly falling in the magnitude range $11.5<V<16.0$, and in the colour range $-0.3<(B-V)<+2.3$.

Only those stars with more than three observations in at least two different nights were retained. A few stars with poor accuracy in the V magnitude were also rejected. The result of the selection is a set of 369 reference stars.

5.5. Number of reference stars per pointing

It is essential to have a sufficient number of photometric reference stars in each field that the OMC is monitoring. Figure 2 shows the percentage of pointings as a function of the number of photometric reference stars inside a circle of radius $2\overset{\circ}{.}26$ (the same area as the $4°\times 4°$ box).

6. Scientific sources

6.1. Gamma-ray sources

The gamma-ray source compilation, at its present status, has been built by collecting all the sources in the 11 original

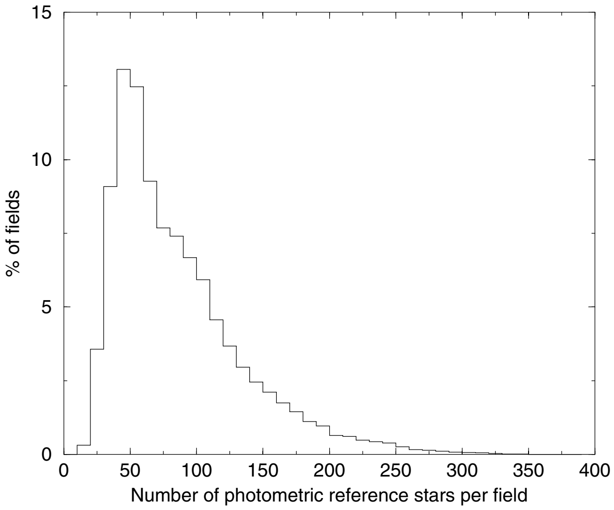

Fig. 2. Percentage of pointings as a function of the number of photometric reference stars inside a circle of radius 2°.26.

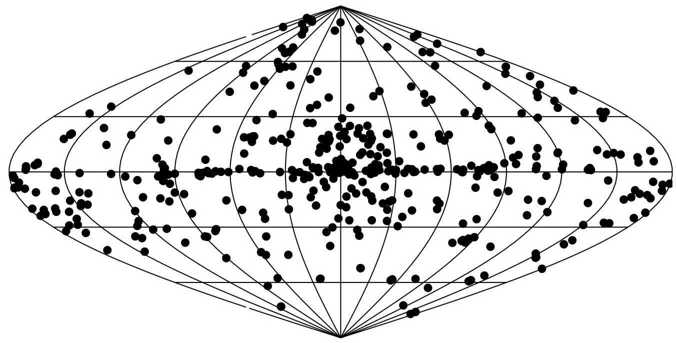

Fig. 3. Sky distribution of the 440 compiled gamma-ray sources in galactic coordinates, with the origin at the centre of the plot and galactic longitude increasing towards the right.

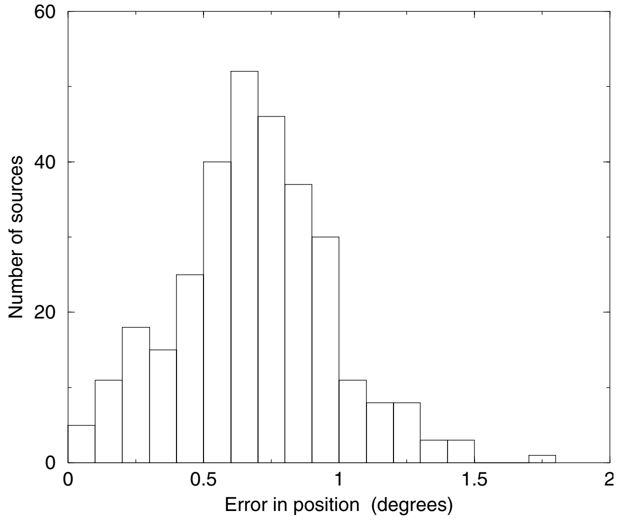

Fig. 4. Distribution of error in position from the original catalogues, available for 313 sources.

catalogues indicated below and the compilation from the *Simbad Astronomical Database* (hereafter SIMBAD):

1. *The Third EGRET Catalogue of high-energy gamma-ray sources* (Hartman et al. 1999);
2. *Point sources of GeV gamma-rays* (Lamb & Macomb 1997);
3. *Supplement to the Second EGRET Catalogue* (Thompson et al. 1996);
4. *EGRET observations of the region to the south of b = −30° in phase 1 and 2 of the CGRO viewing program* (Lin et al. 1996);
5. *The Second EGRET Catalogue* (Thompson et al. 1995);
6. *The First EGRET Catalogue* (Fichtel et al. 1994);
7. *Second COS-B Catalogue of high-energy gamma-ray sources* (Swanenburg et al. 1981);
8. *First COS-B Catalogue: New high-energy gamma-ray sources observed by COS-B* (Hermsen et al. 1977);
9. *First COS-B Catalogue: Present status of gamma-ray astronomy* (Pinkau 1979);
10. *SIGMA survey of the Galactic Center region and discovery of a hard X-ray transient* (Vargas et al. 1996);
11. *Catalogue of SAS-2 gamma-ray observations* (Fichtel et al. 1990).

The compilation contains 440 sources. All available cross-identifications have been used to avoid duplicities. The spatial distribution of these gamma-ray sources is shown in Fig. 3.

6.1.1. Position error from the original catalogues and SIMBAD

In this compilation, 312 sources have astrometric parameters from SIMBAD. In this database, the position error is coded when no information is available from astrometric catalogues. Table 2 shows the errors assigned to these 312 sources in the SIMBAD database. Since the total size of the OMC window allocated to each scientific source depends on this error, this parameter is important for the OMC operations.

Table 2. Number of gamma-ray sources with a specified error from SIMBAD, available for 312 sources.

Error in the position (arcsec)	Number of sources
$\sigma \leq 0.010$	42
$0.010 < \sigma \leq 0.100$	8
$\sigma = 0.300$ (coded)	22
$\sigma = 3.000$ (coded)	30
$\sigma = 18.000$ (coded)	14
$\sigma = 180.000$ (coded)	34
$\sigma = 1080.000$ (coded)	124
$\sigma = 10\,800.000$ (coded)	38

In Fig. 4 the distribution of the position errors taken from the original catalogues is shown. As expected, when optical, radio or X-ray counterparts are known, the errors from SIMBAD are significantly reduced when compared with those from original catalogues. However, when no counterpart is known the errors assigned in SIMBAD can be underestimated.

One of the objectives of INTEGRAL is to provide more precise coordinates of the high energy sources, so the errors in the position of the gamma-ray sources are expected to be reduced in the future.

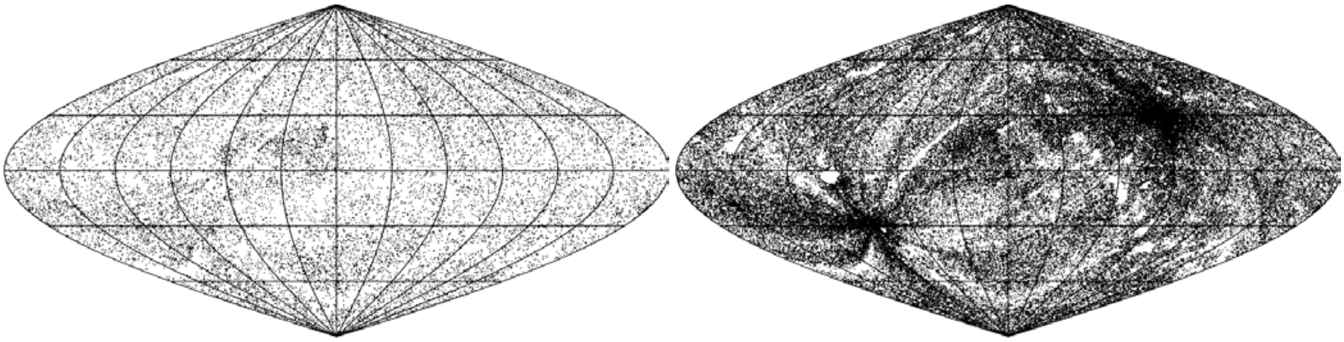

Fig. 5. *Left to right*: Sky distribution in galactic coordinates (with the origin at the centre of the plot and galactic longitude increasing towards the right) of the 18 806 X-ray sources from *ROSAT All Sky Bright Source Catalogue* (RASS-BSC) and 105 924 X-ray sources from *ROSAT All Sky Faint Source Catalogue* (RASS-FSC) contained in the present release of the OMC Input Catalogue.

6.2. X-ray sources

We have taken the *ROSAT All-Sky Survey* (RASS) as the compilation of X-ray scientific sources in our catalogue.

One of the main scientific goals of the ROSAT mission (1990–1999) was to perform the first all-sky survey in X-rays, containing four times more sources than all other existing X-ray catalogues. For this reason, we concentrated our compilation work on ROSAT, not considering older missions, which sampled only a few percent of the sky and were superseded by ROSAT.

The RASS was conducted in 1990/91, and after a second analysis performed in 1994/95, 145 060 sources were detected (detection likelihood ≥7). The brightest 18 806 sources were published in the *ROSAT All-Sky Survey Bright Source Catalogue* (Voges et al. 1999) (hereafter RASS-BSC), whereas 105 924 fainter sources were published in the *ROSAT All-Sky Survey Faint Source Catalogue* (Voges et al. 2000) (hereafter RASS-FSC). Both catalogues have been entirely included in our compilation.

The spatial distribution of these X-ray sources is shown in Fig. 5.

6.3. Optical variable sources

Simultaneus to the monitoring of all the main targets observed by the high-energy instruments, the OMC observes a large amount of optical sources also present in the field of view.

The current compilation includes known galactic and extragalactic variable stars as well as suspected variables. The OMC will substantially increase our understanding on this type of objects since its operational mode allows relatively long and continuous monitoring periods of up to two weeks.

Special care has been devoted to the compilation of extragalactic objects (AGN, QSO, starburst galaxies, narrow emission line galaxies, etc.) as they are potential high-energy emitters. The OMC will do both the analysis of the optical variability of these objects during long periods of time and the compilation of a large database with homogeneus V magnitudes. At present, most of these objects have only B or photographic magnitudes (Padovani 1998).

In the compilation of the optical sources the following eight catalogues and the SIMBAD database have been used:

1. *GCVS* (Kholopov et al. 1998)
   It contains a catalogue of all known galactic variable stars prior to 1997, a catalogue of extragalactic variable stars, a catalogue of supernovae and a catalogue of suspected variable stars not designated as variables prior to 1980 (published in *The New Catalogue of Suspected Variable Stars*, Kukarkin et al. 1982).
2. *New Catalogue of Suspected Variable Stars. Supplement* (Kazarovets et al. 1998)
   It contains 11 206 stars suspected of variability which were not designated as variables prior to 1997.
3. *The 74th Special Name-list of Variable Stars* (Kazarovets et al. 1999)
   It contains 3 157 variable stars whose variability was discovered by the Hipparcos mission. All the stars satisfy the GCVS variability criteria.
4. *Hipparcos Catalogue*
   The 11 597 variable stars in the Hipparcos catalogue have been included.
5. *Variable stars in the Tycho photometric observations*
   To search for variability among faint stars of the Tycho-1 catalogue, Piquard et al. (2001) made a treatment that took into account truncated detections and censored measurements. The list contains 1091 stars suspected to be variable stars.
6. *Quasars and Active Galactic Nuclei, 8th ed.* (Véron-Cetty & Véron 1998)
7. *The Active Galactic Nuclei Catalogue* (Padovani 1998)
   This catalogue includes 12 021 quasars and active galaxies and is heavily based on the catalogue of *Quasars and Active Galactic Nuclei, 7th ed.* (Véron-Cetty & Véron 1996). It also includes the *BL Lac Catalogue* (Padovani & Giommi 1995) updated with BL Lac′s discovered in 1996, and the radio galaxies in the 1 Jy, S4, and S5 radio catalogues. The AGN Catalogue reports V magnitudes almost for all their objects. Nevertheless, in some cases V magnitudes have been derived from B magnitudes by assuming a $(B-V)$ colour index.
8. *Narrow Emission Line Galaxies* (Kunth 1998)
   Compilation of 441 objects dominated by intense starburst

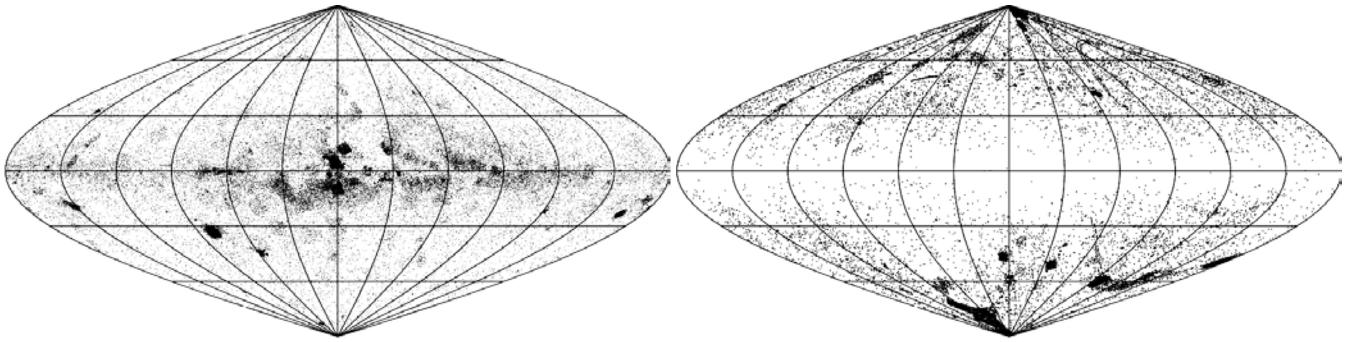

Fig. 6. *Left to right*: sky distribution of the 81 489 galactic and extragalactic variable stars and sky distribution of the 24 960 AGNs, radio-galaxies, narrow emission line galaxies, ... (galactic coordinates, with the origin at the centre of the plot and galactic longitude increasing towards the right).

activity. These objects show strong optical emission lines and/or very blue stellar continuum, both being tracers of young, massive stellar populations and therefore candidates to host supernovae.

When compiling data from all these catalogues, special care has been taken to avoid double entries for the same source. The spatial distribution of the optical sources included in this compilation is shown in Fig. 6.

7. The OMC Pointing Software

The OMCPS acts as an interface between the OMC Input Catalogue, the objects proposed by the observers and the operations of the OMC itself. It is under the responsibility of the OMC team and it was developed at the Astronomical Institute in Ondrejov (Czech Republic).

The OMCPS is running at the ISOC to create the commands required to operate the OMC. It takes into account the strategy of the observation for each pointing, the expected objects in the OMC FOV, their *V* magnitudes and their priorities, allowing to optimize the scientific performances of the instrument.

For each INTEGRAL pointing, the OMCPS generates the corresponding OMC commands. A number of centering and photometric shots (typically one of each kind) as well as the science shots are defined according to several configuration parameters, like the sequence of integration times, the OMC telemetry allocation and the OMC science mode to be used. Astrometric and photometric reference stars (typically ten of each) are extracted from the OMC Input Catalogue. Additional criteria are applied to maximize the average distance among them, and also to select photometric reference stars covering a large range of *V* magnitudes. The scientific targets to be monitored by the OMC in the science shots are selected from the OMC Input Catalogue according to their assigned priorities. Those sources having the same priority are selected as they are found in the catalogue, i.e. by increasing order of right ascension. If the observer proposed one or more targets, they will get the highest priority. For these sources, the OMCPS assigns automatically an OMC identifier starting by "9888" and followed by a running number (starting by "000001") for each observer's source. The origin of this running number is re-set to "000001" when a new pointing starts.

The OMC commands allow to monitor a maximum of 228 targets. However, the maximum number of science sources that can be monitored depends on the OMC telemetry allocation, the size of the sub-windows to be downloaded and the number of sub-windows required for each target. The size of the sub-window has been fixed to 11×11 pixels and typically 100 sub-windows can be downloaded. The OMCPS can generate a mosaic of sub-windows for a given target, depending on its "extension parameter". A maximum value of 900 arcsec has been imposed to the extension parameter, that corresponds to generating a 5×5 mosaic of sub-windows of 11×11 pixels.

8. Some features of the next updates of the OMC Input Catalogue

8.1. Gamma-ray sources

In the present version of the OMC Input Catalogue only gamma-ray sources in the energy range >10 MeV were considered, so the energy range between hard X-ray and soft gamma-ray is not well represented.

Products coming from missions such as BeppoSAX, RXTE and GINGA are not yet included in the current release of the catalogue, whereas data coming from older missions are not archived at any location, as far as we know.

In this compilation, gamma-ray bursts (GRB) are not included. In the next release of the catalogue, we are introducing the few GRB detected by BeppoSAX for which an optical emission has been detected (Pedersen et al. 1998). In addition, the published *General Gamma-ray Source Catalogue* (Macomb & Gehrels 1999), containing 309 objects in the energy range 50 keV–1 TeV is also being fully included in the next release of the catalogue. This will enlarge our compilation by about 70 new sources in the energy range 50 keV–1 MeV.

8.2. X-ray sources

There are other important compilations of X-ray sources that are being studied to be included in next releases of the OMC Input Catalogue. For example, the exhaustive work of compilation which was performed by the XMM-Newton team,

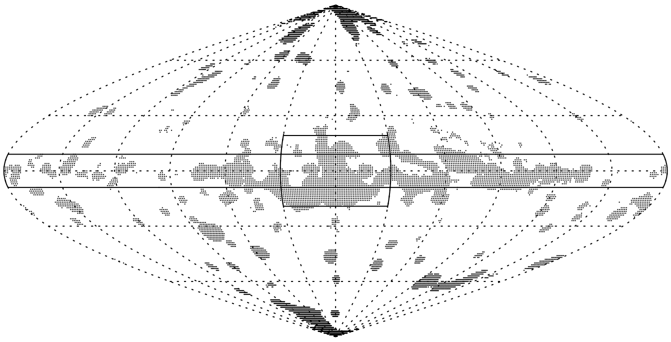

Fig. 7. Black dots represent the fields with 100 or more scientific sources from the OMC Input Catalogue (optical with $V < 18$ or without any known magnitude, X-ray sources and gamma-ray sources). The central square ($\Delta l = 60^{\circ}$, $\Delta b = 38\overset{\circ}{.}4$) and the central belt ($\Delta b = 18^{\circ}$) represent the GCDE (Galactic Central Deep Exposure) and the GPS (Galactic Plane Survey) projections, respectively. Galactic coordinates with the origin at the centre of the plot and galactic longitude increasing towards the right.

resulting in the *XMM-Newton Serendipitous Source Catalogue* (XMM-Newton Survey Science Centre Consortium 2003).

In next releases of the OMC Input Catalogue we plan to give priority to those X-ray sources with known optical counterparts and those expected to be detected by JEM-X (energy band: 3–35 keV).

8.3. Optical sources

We are working to include the new catalogue *Quasars and Active Galactic Nuclei, 10th ed.* (Véron-Cetty & Véron 2001). Other catalogues of variable stars (e.g. Pojmański 1998, 2002) will be also considered in future updates.

9. Conclusions

As a result of our compilation, the OMC Input Catalogue (version 2.0) has 504 819 entries, distributed as follows: 273 200 are astrometric and photometric reference stars, priority 1 has been assigned to 440 gamma-ray sources, priority 2 to the 18 806 bright X-ray sources from the RASS-BSC, priority 3 to the 106 449 optical variable sources from SIMBAD, GCVS (Kholopov et al. 1998), Hipparcos plus some other catalogues and priority 4 to the 105 924 X-ray sources from RASS-FSC.

According to the number of OMC scientific sub-windows that can be downloaded (typically 100), Fig. 7 reveals that new sources should be added to the OMC Input Catalogue. At least those regions of the sky which are candidates to be an INTEGRAL pointing should contain a minimum of 100 selectable OMC scientific targets. Besides the new catalogues listed in Sect. 8, we are working to include other scientific targets of interest in the OMC Input Catalogue, such as emission line stars, stars in the instability strip, white dwarfs or late type main-sequence microvariable sources. Moreover, during the mission, additional sources of interest will be added to the catalogue, namely:

- newly discovered optical counterparts of high-energy sources, especially sources discovered during the Galactic Plane Survey;
- regions of special interest for INTEGRAL science;
- new supernovae;
- new eruptive variable stars;
- any other Target of Opportunity (ToO).

Since the beginning of the OMC operations onboard INTEGRAL, we have verified that the compiled astrometric reference stars work properly, beyond the expectations established before launch. During all the mission time, the onboard centering algorithm has been running smoothly giving the correct solution in all cases. The capabilities of the photometric reference stars to provide an accurate photometric calibration of the instrument as a function of time have been also fully corroborated.

The OMC Input Catalogue (version 2.0) is composed by two separated files: *The OMC Main Input Catalogue* and *The OMC Cross-Identification Catalogue*. The first file contains basic information for the OMC operations, whereas the second one includes several cross-identifiers compiled from original catalogues and the SIMBAD database, as well as some valuable additional information for OMC users. Both files and related documentation can be downloaded from LAEFF home page (`http://www.laeff.esa.es/`).

Acknowledgements. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. OMC has been partially funded by the Spanish MCyT under grants ESP95-0389-C02-02 and ESP2002-04124-C03-01. Work at the Barcelona University was supported by CICYT under contract ESP97-1803. The Czech participation has been funded by the project KONTAKT ES036 by the Ministry of Education and Youth of the Czech Republic and by the ESA Prodex Program 14527.

References

Courvoisier, T. J. L., Walter, R., Beckmann, V., et al. 2003, A&A, 411, L53
Dommanget, J., & Nys, O. 1994, Com. Obs. Roy. Belg., 115, 1
ESA 1997, ESA SP-1200
Fabricius, C., Høg, E., Makarov, V. V., et al. 2002, A&A, 384, 180
Fichtel, C. E., Hartman, R. C., Hunter, S. D., et al. 1990, VizieR Online Data Catalogue, ref. VII/130
Fichtel, C. E., Bertsch, D. L., Chiang, J., et al. 1994, ApJS, 94, 551
Hartman, R. C., Bertsch, D. L., Bloom, S. D., et al. 1999, ApJS, 123, 79
Hermsen, W., Swanenburg, B. N., Bignami, G. F., et al. 1977, Nature, 269, 494
Høg, E., Bässgen, G., Bastian, U., et al. 1997, A&A, 323, 57
Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, A&A, 355, 27
Kazarovets, V., Samus, N. N., Durlevich, O. V., et al. 1998, IBVS, 4655, 1
Kazarovets, A. V., Samus, N. N., Durlevich, O. V., et al. 1999, IBVS, 4659, 1
Kholopov, P. N., Samus, N. N., Frolov, M. S., et al., 1998, Combined General Catalogue of Variable Stars, 4.1 ed. (II/214A)

Kukarkin, B. V., Kholopov, P. N, Artiukhina, N. M., et al. 1982, VizieR Online Data Catalogue, ref. II/140
Kunth, D. 1998, private communication
Lamb, R. C., & Macomb, D. J. 1997, ApJ, 488, 872
Landolt, A. U. 1992, AJ, 104, 340
Lin, Y. C., Bertsch, D. L., Dingus, B. L., et al. 1996, ApJS, 105, 331
Macomb, D. J., & Gehrels, N. 1999, ApJS, 120,335
Mas-Hesse, J. M. 1999, ref. OMC/INT/22000/TNO/004
Mas-Hesse, J. M., Giménez, A., Culhane, L., et al. 2003, A&A, 411, L261
Padovani, P., & Giommi, P. 1995, MNRAS, 277, 1477
Padovani, P. 1998, private communication
Pedersen, H., Jaunsen, A. O., Grav, T., et al. 1998, ApJ, 496, 31
Perryman, M. A. C., Lindegren, L., Kovalevsky, J., et al. 1997, A&A, 323, 49
Pinkau, K. 1979, Nature, 277, 17
Piquard, S., Halbwachs, J. L., Fabricius, C., et al. 2001, A&A, 373, 576
Pojmański, G. 1998, Acta Astron., 48, 35
Pojmański, G. 2002, Acta Astron., 52, 397
Swanenburg, B. N., Bennett, K., Bignami, G. F., et al. 1981, ApJ, 243, 69S
Thompson, D. J., Bertsch, D. L., Dingus, B. L., et al. 1995, ApJS, 101, 259
Thompson, D. J., Bertsch, D. L., Dingus, B. L., et al. 1996, ApJS, 107, 227
Vargas, M., Goldwurm, A., Denis, M., et al. 1996, A&AS, 120, 291
Véron-Cetty, M. P., & Véron, P. 1996, VizieR Online Data Catalogue, ref. VII/188
Véron-Cetty, M. P., & Véron, P. 1998, VizieR Online Data Catalogue, ref. VII/207
Véron-Cetty, M. P., & Véron, P. 2001, A&A, 374, 92
Voges, W., Aschenbach, B., Boller, Th., et al. 1999, A&A, 349, 389
Voges, W., Aschenbach, B., Boller, Th., et al. 2000, IAU Circ., 7432, 3
XMM-Newton Science Survey Centre Consortium 2003, VizieR Online Data Catalogue, ref. IX/37