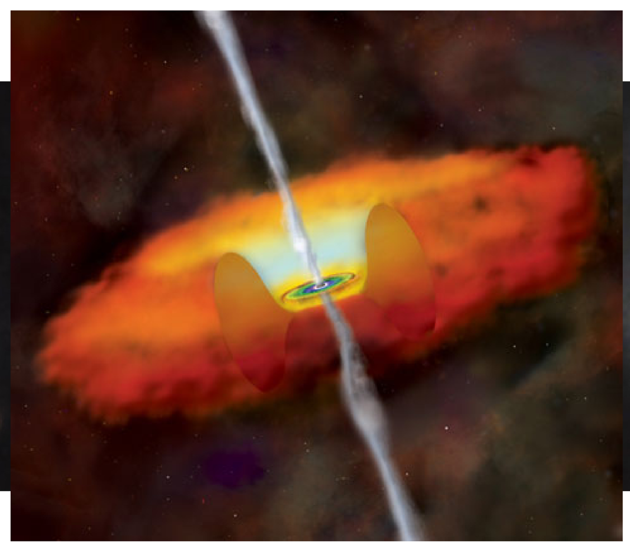

Methods of identification of X-ray sources with small telescopes in optical band

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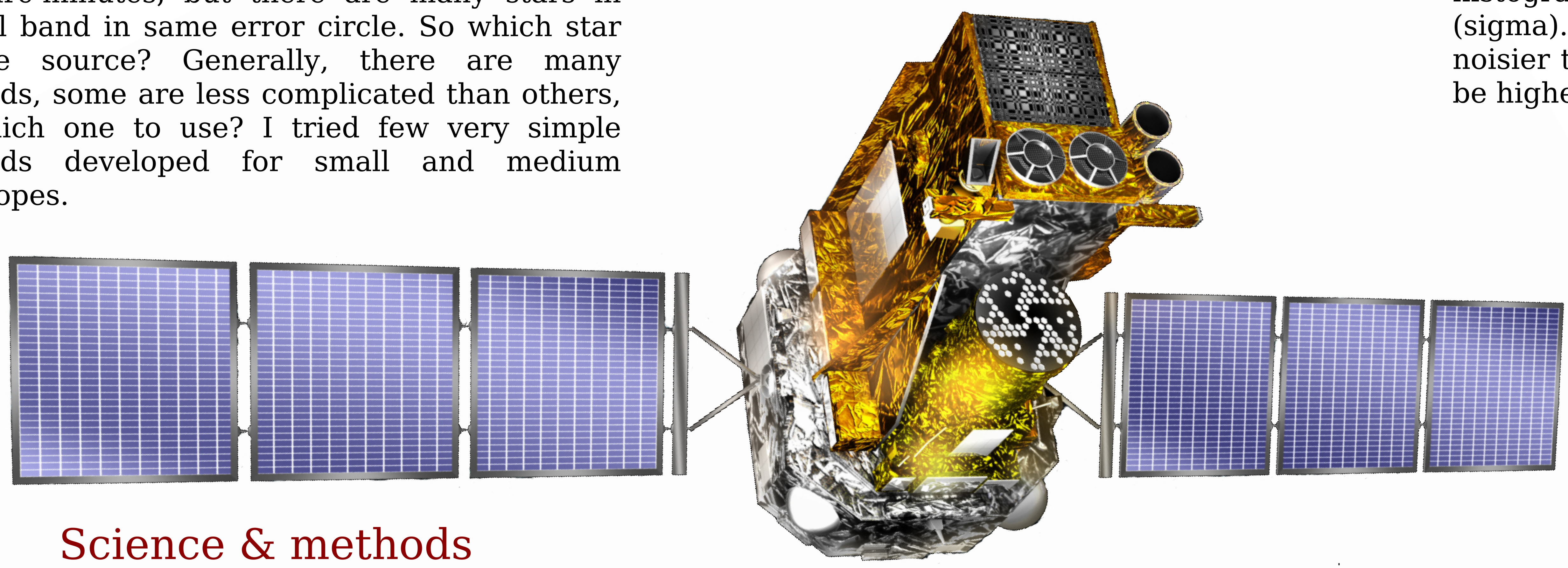
Abstract

Goal of our thesis is to find optical counterparts of selected X-ray and gamma sources measured by INTEGRAL and Swift space missions. Our work also provides basic measurement of short-term variations of sources in optical band, as well as its colour curve and light curve analysis.

Motivation

The motivation of this article is to try identify unknown X-ray sources from INTEGRAL in optical band. There are many unidentificated sources from IBIS surveys. The problem appears to be simple. In X-ray band, there is only one unknown source with position accuracy about tree arc-minutes, but there are many stars in optical band in same error circle. So which star is the source? Generally, there are many methods, some are less complicated than others, so which one to use? I tried few very simple methods developed for small and medium telescopes.



Science & methods

For using these methods, we need to know some basic fact about sources like these. Generally, we know nothing about the source or whether it's from our galaxy or not. We can suppose that many sources are brighter in higher frequencies. Simply, they are blue. We may try to find the bluest ones in error circle of current source. We may also assume that high energetic sources make more noise, simply said, they change their brightness in low time scale more than normal stars. It is something called flickering. These two characters of X-ray sources we try to use.

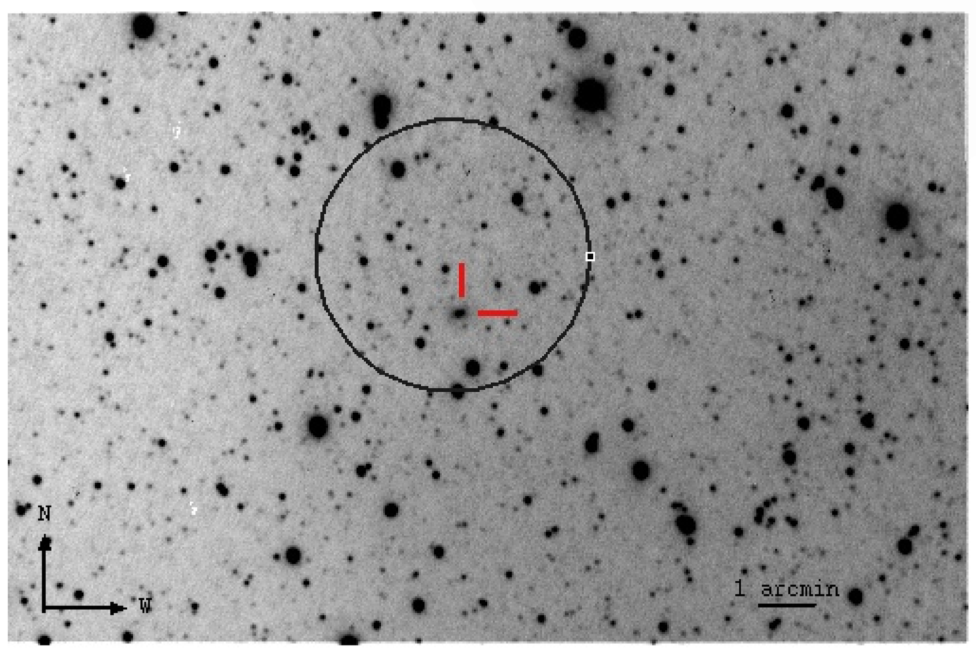


Image of IGRJ00254+6822 from Monteboo observatory, selected object is probably an X-ray source, its galaxy LEDA 136991/IRAS 00227+6805 [1]

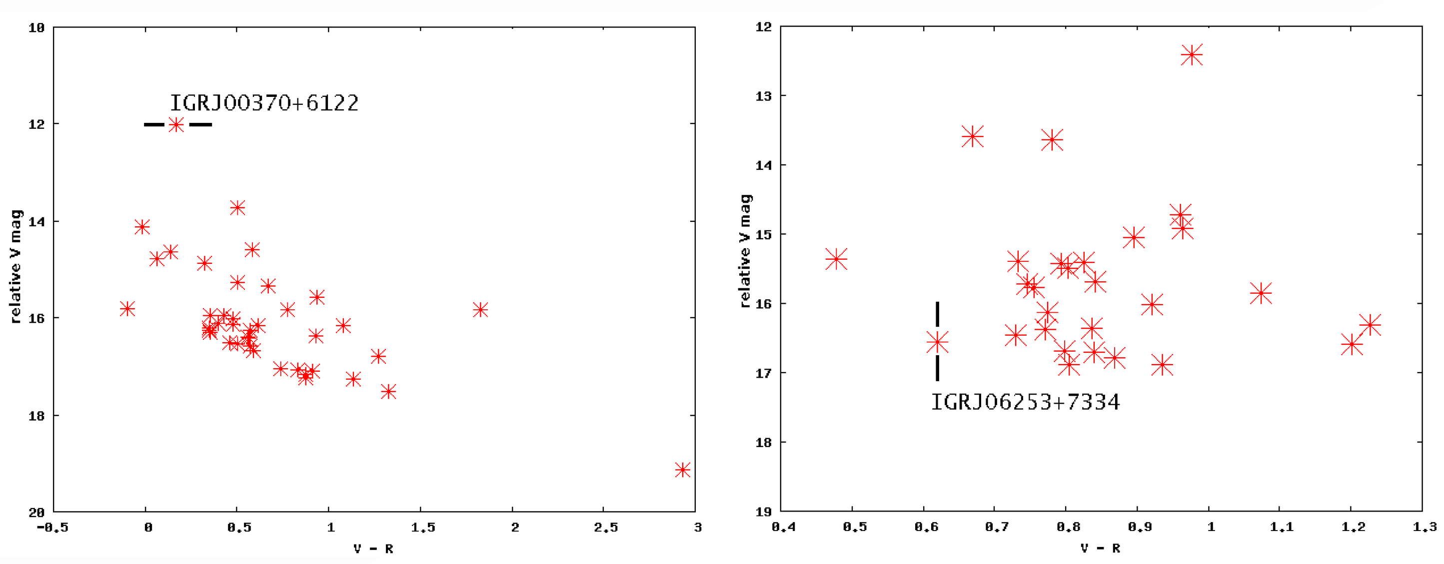
For testing of these well known astrophysical methods we use our 0.6m telescope at Monteboo observatory in Brno, owned by Masaryk University. The telescoppe is equiped ST-8 CCD camera with Johnsons BVRI filters.

We've tried to manage simple menthods also useful for amateur astronomers with no hi-tech astronomical equipment.

Color - Magnitude Diagram (CMD)

An easy way to find out which star from the error circle is bluer, is to make a simple CMD diagram. Which means to construct simple dependences between V minus R color index and V magnitude of all stars in error circle. We do not need to calibrate magnitudes, just make it relatively. The problem is interstellar extinction, which makes further objects more red then they really are. This is only a first approximation, it is giving us a few candidates from dozens of stars, so it has its purpose.

We made this using Munipack astronomy software. Firstly, we combined few images from each bands and then run photometry.



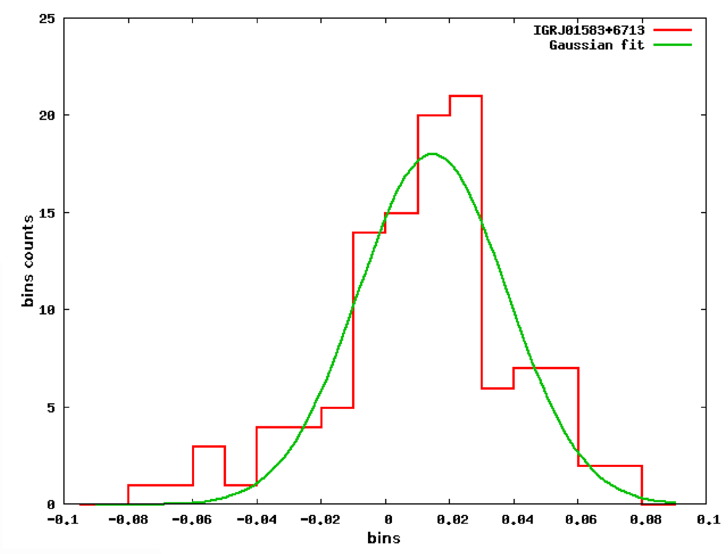
Color magnitude diagram (CMD) of IGR J06253+7334 and IGR J00370+6122 you can see that sources are bluer then most of other stars.

Image of Monteboo Observatory in Brno, 0.6m Newton telescope, Departement of Astrophysics and Theoretical Physics of Masaryk University

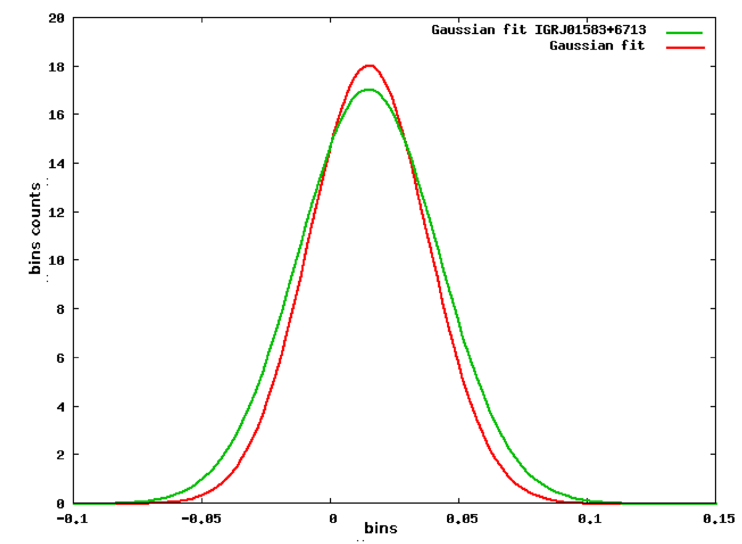
Short term variations

We know from the nature of high energetic sources that the cause of X-ray emissions is accretion disk of very hight temperature or synchrotron emission, mostly combination of both. Both of these make more noise than normal stars, because of fluctuation in accretion disk or some changes in jet. Objects of similar size have short term brightness variations lasting for several seconds and within the frame of hundreds of magnitude.

We can analyze short term variations using histograms of brightness fluctuations. We need to correct data due to trends (straighten trends) and make histograms with right bins.
We apply Gaussian curve to a resulting histogram and compare it's profile half-width (sigma). If we suggest X-ray sources to be noisier than normal stars, their sigma values will be higher.



Gaussian fit on histogram data from IGR J01583+6713 for example.



Example of comparetion of Gaussians fits of the comparative star and the

Conclusions

We tried few methods useful also for amateurs astronomers, we only refer of these methods, because the results are in baccalaureate thesis of MK [2]. For using these methods we recommend telescope bigger then 0.3m. The methods will be used in the future with robotic telescopes BART and D50 in Astronomical Institute in Ondrejov. This is only a tentative identification while the real scientific one should be done according to the spectrum.

References

- [1] ATel #939; L. Kuiper (SRON), P.R. den Hartog (SRON) and W. Hermsen (SRON, Amsterdam) on 8 Nov 2006;
- [2] Methods of identifications of X-ray sources in optical band; M. Kocka, bachelor`s thesis, Masaryk University, Brno 2008
- [3] Computer Programs for CCD Photometry; F. Hroch, 1998stel.conf...30H