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Correlation of Optical and X-ray Radiation of NGC 4151 and 3C 390.3. Preliminary Results

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Abstract. The correlation of optical and X-ray radiation of some AGN is studied. We used low signal-to-noise data from the All-Sky Monitor of the Rossi X-ray Timing Explorer (2-10 KeV) and broad-band photometry of the optical continuum obtained mainly during the last several years through the "AGN Watch" program.

1. Introduction

Presently achievable angular resolution is not enough to get an image of the AGN "central engine". So, indirect methods are the only way to study the region of AGN energy output. The reverberation mapping method (RMM) is the most developed one. For its realization, it is necessary to use long, well sampled data sets, which can be provided only by an international monitoring program.

The theoretical basis of the RMM suggests analysis of the optical line profile response following variations of the X-ray continuum. Actually, the optical continuum is used instead of the X-ray one. Therefore it is very important to know the relationship between variations of the X-ray and optical continua.

2. Observational Data

We used X-ray data (2-10 keV) from the All-Sky Monitor (ASM) of the Rossi X-ray Timing Explorer for 1997-2000 for NGC 4151 and 3C 390.3. Note particularly that we used the ASM measurements in contrast to other investigations. The reason is that it is the only long-term (from 1986 up to now) homogeneous set of X-ray data, but the signal is rather small relative to the ASM background.

Optical photometric observations were made mainly in 3 observatories: the Crimean Laboratory of the Sternberg Astronomical Institute, the Special Astrophysical Observatory (North Caucasus) and Mt.Maidanak Observatory (Uzbekistan). V.M. Lyuty reduced the full list of data to one photometric system for an aperture of 27.5".

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3. Results

A preliminary estimate of the correlation coefficient of the X-ray and optical radiation (U-band for NGC 4151 and B-band for 3C 390.3) was made. On account of the rather low S/N ratio for the X-ray data, we carried out a several-day average in order to increase the contribution of the X-ray signal relative to the noise.

From the optical light curves we removed the long-term ($\sim$ years) component, which has no X-ray analog. The relationship of variations in the optical and X-ray continua was considered after that.

For NGC 4151, the maximum estimate of the correlation coefficient corresponds to 5-day averaged X-ray data and is equal to 0.53. Cross-correlation analysis shows that the time lag of the optical continuum with respect to the X-ray flux is $< 1^d$. Therefore, in this particular case the existing photo-ionizing source seems to have a dimension less then one light-day and the reverberation mapping method may at least be used to search for structures significantly larger than one light-day.

For 3C 390.3 we did not find a significant correlation of the optical light curve and the X-ray flux. Possible reasons may be: 3C 390.3 has a low mean signal – about 0.2 count/sec, as opposed to 0.6 for NGC 4151. Perhaps the absence of correlation is connected with insufficiently accurate registration of the background or its variability. The signal distribution shows that within 2σ limits, the statistics are approximately normal, with a standard deviation about 0.3 c/s (for one-day average data), but for large signal absolute differences ($> 2\sigma$) the negative wing of the distribution is stronger than the positive one.

It could be evidence of inadequate calculation of background variations produced by solar activity events. The other possible reason for a negative result is some peculiarity of source structure (scattering in the disk corona, binary black hole, etc.).

4. Conclusion

Preliminary estimates of the correlation coefficient of the optical and X-ray continua for 3C 390.3 (in this case, we did not find a significant correlation) and for NGC 4151 (the estimate is about 0.53, sigma is about 0.22) were made. No time delay greater then one day was found and the upper limit is ~ 1 day.

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