# X-RAY INTENSITY VARIATIONS IN BL LAC SOURCES H2155-304 AND PKS 0548-322

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ABSTRACT: The X-ray Observations of two BL Lac Objects H2155-304 and PKS 0548-322 made with HRI and MPC on the Einstein Observatory show intensity variations on time scale of hours in both the sources. X-ray spectra of the two BL Lacs are derived. Limits on the mass of the accreting compact objects are obtained from time scale and magnitude of variations. Implications of the results are briefly discussed.

In this paper we report variations in the X-ray intensity and spectra of two BL Lac objects H2155-304 and PKS 0548-322. The results are based on observations made with the High Resolution Imager (HRI) for about $10^4$ S for each source and Monitor Proportional Counter (MPC) on the Einstein Observatory. The HRI field of view was centered on the two BL Lac objects and the MPC data were obtained simultaneously.

The positions of the X-ray sources obtained from the HRI images agree well with the radio and optical positions of the two BL Lac sources to within 0.6", thus confirming their identification. From the observed radial surface brightness distribution of the X-ray sources, it is inferred that the extent of the sources is $\leq$ 1" which implies a linear extent of $\leq$ 2.7 kpc for H2155-304 and $\leq$ 1.8 kpc for PKS 0548-322 (Hubble Constant = 50 km $s^{-1}$ $Mpc^{-1}$).

X-ray light curves in the soft energy band (0.1 - 4.5 KeV) of HRI show X-ray flux variation by about 20% over time scale of 8 hours for H2155-304 whereas it is nearly constant for PKS 0548-322 for the entire duration of observations. Correlated but much larger intensity variations are detected in 1.2 - 3.5 KeV (by $\sim$ 40%) and 3.5 - 10 KeV (by $\sim$ 100%) bands of MPC for H2155-304. In case of PKS 0548-322 no significant intensity variation is detected in 1.2 - 3.5 KeV band. But its intensity changed by a factor of two in about an hour in 3.5 - 10 KeV interval.

X-ray spectra of the two BL Lac were derived for different time intervals from the MPC data in 1.2 - 10 KeV range. No reasonable fits were obtained for any set of observed spectra with either thermal bremsstrahlung or exponential or black-body models. The spectra are however well fitted with power law models for some of the epochs. The best fit energy spectral



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index ($\alpha$) is found to vary between 1.9 and 2.6 for different epochs for H2155-304. However the significance of these variations is small due to poor spectral fits and the spectral fits are consistent with a constant value of $\alpha = 2.16$. The spectral index for PKS 0548-322 is observed to vary largely between 1.0 and 1.6 with the exception of one epoch where the best fit value of $\alpha$ is as high as 0.5. The average value of $\alpha$ for this source is 1.14. There is a slight indication that the source spectrum is flatter when the flux is higher.

Comparing the flux values and spectra derived from present observations with those obtained earlier by several researchers (for a summary see Urry 1984), it is concluded that there exist long term intensity and spectral changes in both the BL Lac sources. A large change in the average intensity of H2155-304 is observed over the years 1978 to 1979.

The results presented here confirm the earlier reports of variability over time scale of less than a day by Agrawal and Riegler (1979) and Synder et al (1980) in H2155-304. The X-ray spectra of the two BL Lacs are very much softer than those of the Seyfert galaxies. From the rapid variability constraints can be placed on the nature and origin of apparently non-thermal X-ray emission from the two BL Lacs. Assuming that the sources are powered by accretion onto a massive black hole, an upper limit on the black hole mass is obtained by requiring that the fluctuation time be longer than the light travel time across a radius 10 times the Schwarzschild radius. Lower limit on the mass of the accreting object is obtained from the requirement that the luminosity should not exceed the Eddington Limit. Using the observed time scale of intensity variations and magnitude of luminosity changes the following mass limits are obtained : $1.6 \times 10^7\ M\odot \leq M \leq 6 \times 10^8 M\odot$ for H2155-304 and $6 \times 10^6\ M\odot \leq M \leq 8 \times 10^7\ M\odot$ for PKS 0548-322. These variations are further consistent with $\sim$ 10% efficiency for conversion of matter into radiation at the origin of X-rays from a central source in a BL Lac.

The very soft, power law ($\alpha > 1$), low energy ($< 10$ keV) spectra and indication of the presence of a variable flat high energy extension for the BL Lacs are similar to those found previously for some other BL Lacs, like Mrk 421 and Mrk 501 (Mushotzky et al. 1979, Worrall et al. 1981). A plausible explanation is that the low-energy X-ray component is the high frequency tail of a synchrotron spectrum which extends from the radio region, while the higher energy X-rays are produced by first-order compton scattering of the synchrotron photons (SSC models). In these non-thermal emission models, an increase in intensity should result from an injection of energetic particles or change in the acceleration rate, and the entire spectrum from radio to X-rays should rise uniformly.

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