Optical Photometric Monitoring of Gamma-Ray Bright BL Lacertae Objects

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BL Lacertae objects are the most extreme members of a class of objects known as Active Galactic Nuclei. Most models of the AGN phenomena involve a central, supermassive black hole, surrounded by an accretion disk. Perpendicular to the accretion disk are two jets of material, and the type of source we see depends on the angle the jets make with the line of sight and the strength of the jet itself. In the case of BL Lac objects, the jets are aligned with the line of sight, and the radiation is being beamed directly at us. The defining characteristics of BL Lac objects are large amplitude continuum variability at all wavelengths, a featureless optical continuum, and large amplitude, highly variable polarization. Variations on the timescale of hours are known as microvariability, and represent the fastest variations observed in these sources and thus (via light travel time arguments) provide the tightest constraints on the size of the emission region. Since BL Lac objects do not vary at regular intervals, it is important to understand what causes the variability. One current model of the physics of the jets theorizes that radio and optical radiation are up-scattered through external inverse Compton scattering to gamma-ray radiation (Ghisellini & Maday, 1996). Thus we have chosen to observe several gamma-ray bright BL Lac objects in order to test this model. The model predicts that there will be a wavelength dependent lag in the variability and that this variability will be on short timescales. The goals for this project consisted of 1) setting limits to the size of the emission regions responsible for any observed microvariability and 2) testing models of the jet physics and of the origin of the seed photons responsible for the observed gamma-ray emission. Data for this project was obtained by the 0.6m telescope at the Bell Observatory of Western Kentucky University and the 42-inch Hall Telescope at Lowell Observatory. The images from Lowell Observatory were made with the B and I filters of the object 0716+714. The images from Bell Observatory were made with the V and I filters of the objects OJ 287 and 3C 66A, and with the B and I filters of the object BL Lac. Data Analysis was done using the Image Reduction and Analysis Facility (IRAF). Each image was reduced by subtracting the bias and dark current, removing any non-linearity, and measuring the brightness of the object and each of the comparison stars. The differential magnitudes of the object and the comparison stars were then obtained. The error was the standard deviation of the differential magnitude of the comparison stars. Preliminary analysis of the Lowell data shows no lag in the variability between the B and I bands. Also noteworthy is that the amplitudes of the variations are smaller in the B than in the I band. Error for this data set was approximately 0.005 magnitude. Cross-correlation still needs to be done for this data; however the preliminary analysis implies that the model tested is not a good model, at least for this object. Analysis of the Bell data has not been completed at this time. Preliminary analysis of the BL Lac images shows no conclusive evidence of wavelength dependent lag or microvariability, probably because there was not enough data for each night and not enough nights of data overall.

Ghisellini, G. and Maday, P., 1996, MNRAS, 280, 67.