Periodicity Felicity: Identification of Binary Black Hole Candidates through Robust Light Curve Analysis

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Binary supermassive black holes are expected to be common at the centers of galaxies. No observational technique has the resolution to directly image them. One indirect way to confirm their presence is to look for periodic variations in their light curves. However, most light curves of blazars (galaxies whose central black hole(s) are active and produce enormous amounts of radiation some of which comes from a jet pointed in our direction) only go back a few decades since blazars were only discovered in the mid-twentieth century. This is a severe problem since the timescale of variations are expected to be of the order of a decade. Fortunately, the Harvard College Observatory has been monitoring some blazars (mistaken to be stars) since the mid-nineteenth century. These observations have recently been digitized. I obtained this publicly available data, learned about different Spectral Analysis algorithms, selected the most appropriate ones, and wrote code in order to look for periodicity in the optical light curves of 13 of the brightest quasars. I then used sinusoidal least-square regression to find the best fitting model of the lightcurve data for each significant periodicity in each source. Multiple complementary methods were used to determine whether each lightcurve has a periodic component. The standard residual error of each model was calculated in order to assess the relative strength of each model quantitatively. Four periodicities among three sources (OJ287, 3C273, OI090.4) were found to be significant. Three of these concur with previous published research thus confirming the validity of my analysis methods. The periodicity detected in OI090.4 has not been previously reported, suggesting it is a new binary black hole candidate.

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Third Award of $1,000