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# SEARCHING FOR PERIODICITIES IN AGN

ANDJELKA KOVAČEVIĆ[1], LUKA Č. POPOVIĆ[2]

[1]*Department of Astronomy, Faculty of Mathematics, Studentski trg 16, 11000 Belgrade, Serbia*
[2]*Astronomical Observatory Belgrade, Volgina 7, 11060 Belgrade, Serbia*
E-mail: andjelka@matf.bg.ac.rs

**Abstract.** Active Galactic Nuclei (AGNs) often show high variability in the spectral lines and continuum. This variability may be periodical, that may indicate a binary black hole in the center of some AGNs. Here we applied method of continuous wavelet transform for periodicity searching in the optical spectra of 3C390.3. There is a chance that long term variability is present.

## 1. INTRODUCTION

Active galactic nuclei (AGN) often exhibit variability in the broad emission lines. The region where broad lines are formed (hereinafter BLR – broad line region) is close to the central supermassive black hole and may hold basic information about the formation and fueling of AGN.

A long-term spectral monitoring of the nucleus of some AGN has revealed a time lag in the response of the broad emission lines relative to flux changes in the continuum. This lag depends on the size, geometry, and physical conditions of the BLR. Thus, the search for correlations between the nuclear continuum changes and flux variations in the broad emission lines may serve as a tool for mapping the geometrical and dynamical structure of the BLR (e.g., Peterson, 1993).

Studies of the variations in both the continuum and broad emission-line profiles and their correlations can provide information about the BLR physics (see e.g., Shapovalova et al., 2009).

## 2. OBSERVATIONS

Spectra of 3C 390.3 (during 158 nights) were taken with the 6 m and 1 m telescopes of the SAO RAS (Russia, 1995–2007) and with INAOE's 2.1 m telescope of the "Guillermo Haro Observatory" (GHO) at Cananea, Sonora, Mexico (1998–2007). They were acquired using long-slit spectrographs, equippedwith CCD detector arrays. The typical wavelength interval covered was from 4000 Å to 7500 Å, the spectral resolution varied between 5 and 15 Å, and the S/N ratio was > 50 in the continuum near Hα and Hβ. Spectrophotometric standard stars were observed every night.

The spectrophotometric data reduction was carried out using either the software developed at SAO RAS or the IRAF package for the spectra obtained in Mexico. The image reduction process included bias and flat-field corrections, cosmic ray removal, 2D wavelength linearization, sky spectrum subtraction, addition of the spectra for every night, and relative flux calibration based on standard star observations.

## 3. METHOD AND RESULTS

Searching for periodicity has been an important part of variability studies of AGN, because the confirmed periodicity would strongly constrain possible physical models and help us to determine the relevant physical parameters of AGN.

We therefore applied a wavelet transform with the Morlet wavelet to see if there is periodicity in the continuum light curve. Wavelet analysis involves a transform from one-dimensional time series to a diffuse two-dimensional time-frequency image for detecting localized (pseudo-) periodic fluctuations from subsets of the time series corresponding to a limited time span (Torence and Compo, 1998).We employed the standard wavelet codes of Torence and Compo (1998) to look for periodicities in the 3C 390.3 optical-continuum and Hβ light curve.

A Morlet wavelet is particularly suited to the analysis of time series and has been successfully applied to study variability in AGN (i.e. Lachowicz et al., 2009).

We therefore employ a Morlet wavelet here, which is defined as

$$\Psi_t(s) = \pi^{-1/4} e^{ikt} e^{\frac{-t^2}{2s^2}}$$

where $t$ is the time parameter, $\pi^{-1/4}$ is the normalization factor, and $s$, $k$ are wavelet scale and oscillation frequency parameter, respectively. The parameter $k$ has been set equal to 6 to satisfy the admissibility condition.

The continuous wavelet power spectra is subjected to the edge artefacts because the wavelet is not completely localized in time. It is useful to introduce a cone of influence (COI) in which the transform suffers from these edge effects (Torence and Compo, 1998). Periods inside the COI are subjected to edge effects and might be dubious.

Figures 1 and 2 show the continuous wavelet power spectra of the long-term light curve in the optical continuum and Hβ, respectively. There are evidently common features in the wavelet power of the tree time series. Both wavelet spectra have a long-term periodicity (1.7 and 2.17 yr) in the late part of the light curve, above the 95 % confidence level, but within the COI (periodicity being too close to the total signal length).

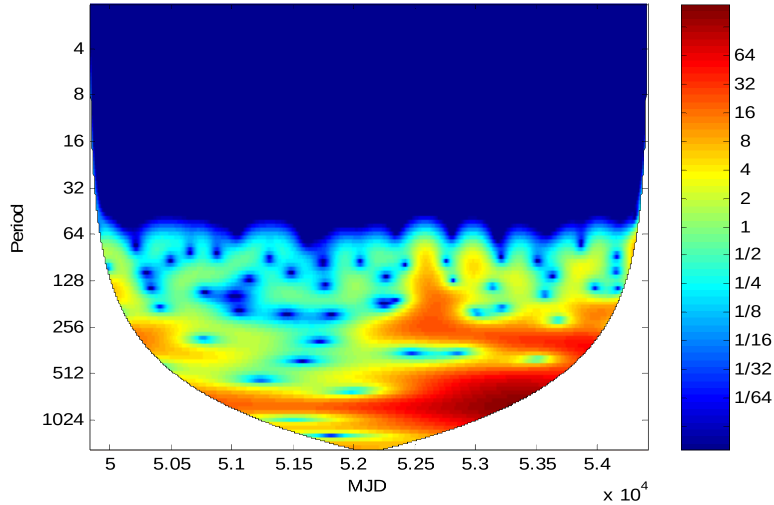


**Fig. 1.** Continous wavelet transform of optical continuum 3C3903.3 Calculated periodicity 630 days (1.7 years).

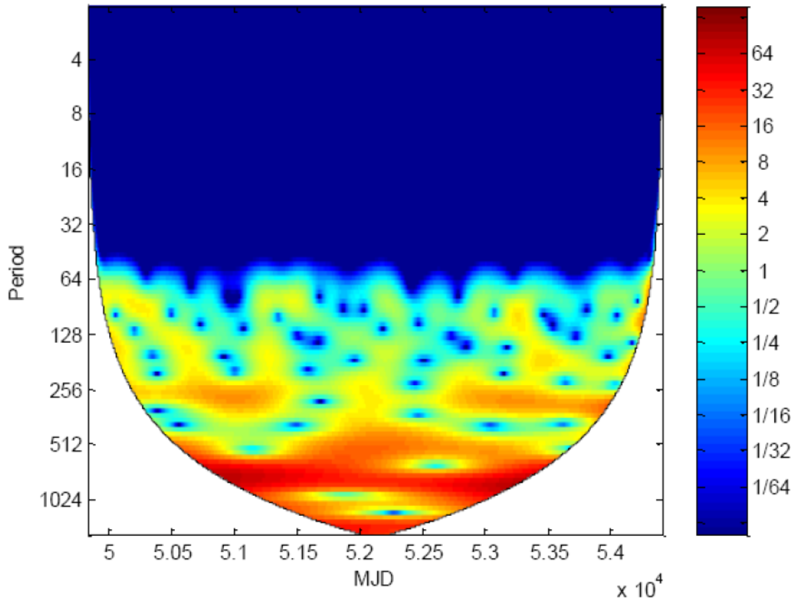


**Fig. 2.** Continous wavelet transform of Hβ light curve of 3C3903.3. Calculated periodicity 792 days (2.17 years).

## 3. CONCLUSIONS

We found indices of long term variability (LV) in the Hβ and continuum light curve, as commonly observed for stellar-mass black holes.

The periodicity of the light curves is probably connected with some shock waves near the supermassive black hole spreading in the outer part of the disk, but on the other hand, we cannot exclude the contribution of either ejection or jets to LV.

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