Intra-night optical variability study of radio-flared radio-quiet narrow-line Seyfert 1 galaxies

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ABSTRACT

AGN variability on minutes to hour-like timescales in the optical waveband is termed as intra-night optical variability (INOV). Such variations are used as an alternative tool to indirectly verify the presence of jets in AGNs. Here, we report the first attempt to systematically characterize INOV for a sample of radio-quiet narrow-line Seyfert1 galaxies (RQ-NLSy1s) that had shown multiple flaring at 37 GHz in the radio observations of Metsahovi radio telescope but no jet counterparts in the recent radio observations of Karl G. Jansky Very Large Array (JVLA) at 1.6, 5.2, and 9.0 GHz. Thus, It is unclear if these NLSy1s possess relativistic jets that cause flaring at 37 GHz. A total of 28 intra-night sessions, each lasting >3 h was conducted for the INOV study of this sample. In our analysis, special care has been taken to address the possible effect on the differential light curves, of any variation in the seeing disc during the session, since that might lead to spurious claims of INOV from such AGN due to the possibility of a significant contribution from the host galaxy to the total optical emission. From the current sample of RQ-NLSy1s, a duty cycle (DC) is estimated to be around 20 percent, which is approaching to DC of γ-ray detected radio-loud NLSy1s, that display blazar like INOV. This suggests that a few of the sources from the current sample possess relativistic jets even though being radio-quiet and an order less massive than jetted-RLNLSy1s.

1. Introduction

- NLSy1 galaxies are a special class of lower-luminosity AGNs defined by (i) Balmer emission line FWHM(Hβ) < 2000 km s^{-1} (ii) flux ratio of [OIII] λ5007/Hβ < 3 and (iii) having strong permitted optical/UV FeII emission lines (Osterbrock D.E et al. 1985, Grupe et al. 1999).
- Until recently, jets were thought to be launched from radio-loud AGNs. However, recently, a small sample of seven radio-quiet and/or radio-silent (never detected in radio) NLSy1s had shown multiple flaring at 37 GHz when they observed with Metsähovi Radio Telescope (Lähteenmäki et al. 2017, 2018). This strongly suggests the presence of jets in these RQNLSy1s.
- However, when these RQNLSy1s were observed with Karl G. Jansky Very Large Array (JVLA) at three different frequencies, 1.6 GHz, 5.2 GHz, and 9.0 GHz, no jet counterparts were detected from them (see Berton et al. 2020).
- Since INOV is used to indirectly verify the presence or absence of jets in other subclasses of AGN because of the well-established observational fact that for radio-loud jet-dominated sources, such as blazars, both INOV amplitude and DC, are found to be distinctively high in comparison to non-blazars class of AGN. Therefore, the detection of multiple flaring from the above sample of seven RQ-NLSy1s at 37 GHz strongly motivates us to do the INOV study of this sample.

2. Sample selection

- A sample of seven RQ-NLSy1s was selected from Berton et al. 2020.

3. Observation and Data Reduction

- Observations of seven RQ-NLSy1s were carried out with two telescopes 1.04m and 1.3m from Aryabhatta Research Institute of Observational Sciences, India, and another two telescopes 1.2m and 2.5m from Physical Research Laboratory, India.
- Data reduction was done using standard tasks in the Image Reduction and Analysis Facility (IRAF).
- The instrumental magnitude of RQNLSy1 galaxies and comparison stars were determined by aperture photometric technique using the Dominio Astronomical Observatory Photometry II (DAOPHOT II) algorithm.
- Since we are interested to search INOV in the current sample of seven RQ-NLSy1s, therefore, a differential photometric technique is being used here.

4. Results

- Observations of seven RQ-NLSy1s were carried out in a total of 28 intranight sessions each > 3 hours.
- Significant INOV with amplitude of INOV (Ψ > 10%) was detected in five intra-night sessions including a probable variable session with conservative F^{η}-test.
- However, strong INOV with Ψ > 10% was detected in the ten intra-night sessions including two probable variable sessions when Fenh-test was used.

Table 1: Duty cycle and amplitude of INOV (Ψ) for the current sample of 7 RQNLSy1s based on the two versions of F-test.

F^{η}-test		F_{enh}-test	
DC (%)	$\overline{\Psi}^{\dagger}$ (%)	DC (%)	$\overline{\Psi}^{\dagger}$ (%)
14.3 (17.5)	19.2 (22.0)	27.7 (35.0)	18.9 (17.1)

†The mean value for all the DLCs belonging to the type 'V'.
⊥Values inside parentheses are resulted when 'PV' cases are considered to 'V'.

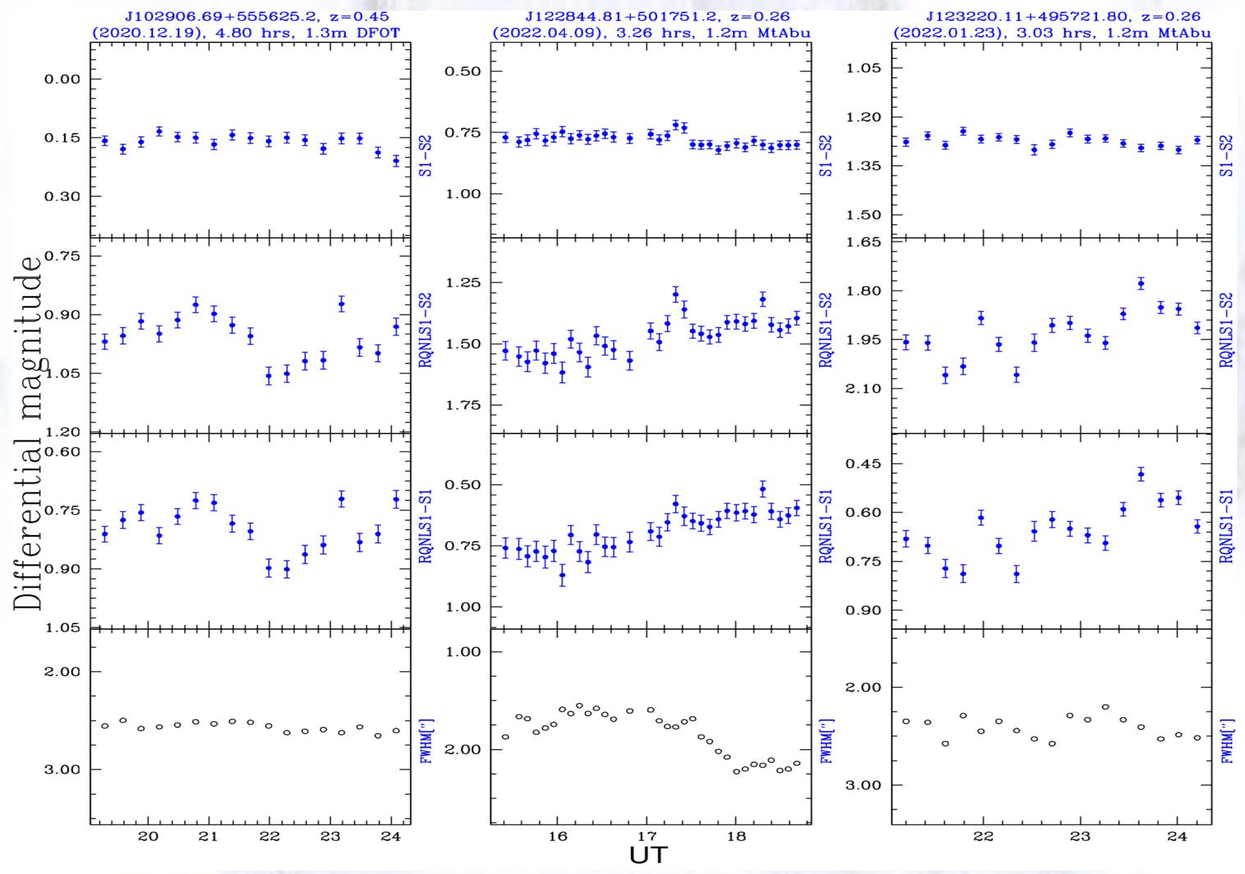

Figure 1: A mosaic of three variable ('V') sessions of three different RQNLSy1s from the current sample is presented. In each panel, the upper DLC is derived using the two non-varying comparison stars, while the lower two DLCs are the 'RQNLS y1-star' DLCs, as defined in the labels in each panel. The variation of the seeing conditions (FWHM in arcsec) during the monitoring session is plotted in the bottom panel.

5. Conclusions & Future work

- From the current sample of RQ-NLSy1s, a duty cycle (DC) is estimated to be around 20 percent, which is approaching to DC of γ-ray detected radio-loud NLSy1s, that display blazar like INOV.
- This suggests that a few of the sources from the current sample possess relativistic jets even though being radio-quiet and an order less massive than jetted-RLNLSy1s (see Ojha et al. 2022).
- Very Long Baseline Array (VLBA) observations at higher frequencies of RQ-NLSy1s that had shown INOV in the current work may be revealed radio jets from RQ-NLSy1s.

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