



Quasar Candidates behind the Milky Way Disk and M31

Tímea Kovács^{1,10}, Georgía Loukaidou^{2,10}, Clara Pennock^{3,10}, Teymoor Saifollahi^{4,10}, Gabriele Umbrico^{5,10},
Valentin D. Ivanov^{6,10} , Petko Nedialkov⁷ , Heidi Korhonen^{8,10}, Alessandro Pizzella^{5,10} , Luca Costantin^{5,10}
[+ Show full author list](#)

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timea.kovacs95@gmail.com

¹ Eötvös Loránd University, Hungary

² University of Athens, Greece

³ Keele University, UK

⁴ University of Groningen, The Netherlands

⁵ Università degli Studi di Padova, Italy

⁶ ESO Garching, Germany

⁷ Sofia University, Bulgaria

⁸ DARK, Denmark

⁹ Finnish Centre for Astronomy with ESO, Finland

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Valentin D. Ivanov <https://orcid.org/0000-0002-5963-1283>

Petko Nedialkov <https://orcid.org/0000-0002-9970-9591>

Alessandro Pizzella <https://orcid.org/0000-0001-9585-417X>

Marco Berton <https://orcid.org/0000-0002-1058-9109>

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Quasars behind the Milky Way, M31 and other nearby galaxies are useful for absorption line studies. Here we report spectroscopic follow-up of four quasar candidates behind the Galactic plane and two behind the Andromeda galaxy. The targets were selected among the brightest objects classified as quasars in Flesch (2016)

that are lacking spectroscopic confirmations and are located in the general direction of the Galactic anti-center or behind M31's main body (avoiding the most obscured regions). Our goal was to verify their nature and, if they are quasars, to measure their redshifts.

The observations were performed in the framework of the 2018 OPTICON NEON Observing School¹¹ at the Asiago Astrophysical Observatory (Italy) between 2018 September 13 and 18 with the 1.22 m *Galileo* telescope, operated by the University of Padova, (for 2MASS J00450929+4202393 and 2MASS J00471445+4202098; 2''/56 (150 micron) wide slit, grating 300, resolving power $R \sim 1000$; the total integration times were 120 and 100 minutes, respectively, split in 20 minutes exposures) and with the 1.82 m Ekar *Copernico* telescope, operated by the Astronomical Observatory of Padova that is part of the National Institute of Astrophysics (for 2MASS J02155016+4806200, WISEA J023648.12+442520.2, WISEA J185756.83+321653.3, WISEA J212638.33+333212.0 and SDSS J222254.5; slit 1''/26, grating GR04, $R \sim 500$; total integrations 20, 38.25, 40, 20 and 50 minutes, respectively, split in 20–30 minutes exposures). The data reduction was carried out with IRAF and followed the usual steps for long-slit spectra: bias subtraction, flat-fielding and 1D extraction, wavelength calibration (with FeAr lamp for the 1.22 m data and Th lamp for the 1.82 m). The flux calibration was based on standards from Oke & Gunn (1983), Oke (1983), Hamuy et al. (1992, 1994). Typically, the weather condition were mediocre: thin-to-thick clouds, high humidity and $\sim 2''$ seeing. The final spectra are shown in Figure 1.

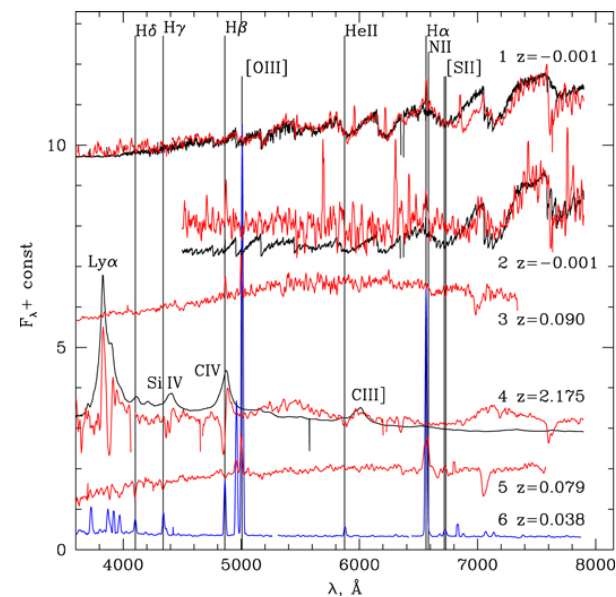


Figure 1. Observed spectra (red/blue; smoothed and shifted vertically for clarity, at rest-frame, except for object 5 shown at observer frame; for the two stars we adopted $V_{\text{rad}} = -300 \text{ km s}^{-1}$ for M31 from McConnell 2012) of: 1. 2MASS J00450929+4202393, 2. 2MASS J00471445+4202098, 3. 2MASS J02155016+4806200, 4. WISEA J023648.12+442520.2, 5. WISEA J185756.83+321653.3 and 6. WISEA J212638.33+333212.0. Comparison spectra (black): M3III BS 4463 for object 1 and M4III SHV0549503.dat for objects 2 (Chen et al. 2014), and the SDSS composite quasar spectrum (Vanden Berk et al. 2001) for object 4.

WISEA J023648.12+442520.2 ($l \sim 142.0$ $b \sim -14.5$) is, as we have found, a quasar with broad Ly α , Si IV, C IV lines, but strong intervening absorptions—probably from material associated with the quasar—made these ill-suited to measure the object's redshift. The weaker C III line, affected by absorption to a lesser degree, yielded a tentative redshift $z = 2.175 \pm 0.005$.

Multiple narrow lines (H α , H β , [O III], [S II], etc.) were detected in the spectrum of WISEA J212638.33+333212.0 ($l \sim 81.3$ $b \sim -12.3$). We measured $z = 0.0379 \pm 0.0002$. The extinction toward this galaxy from the Balmer-decrement is $A_V = 0.87$, and the star formation rate—from the extinction-corrected H α and H β luminosities is star formation rate = $50 \pm 2 M_\odot \text{ yr}^{-1}$, using a calibration from Kennicutt (1998) with Chabrier (2003) IMF. The location of the galaxy on the BPT diagram ([O III]/H β) = 0.9 versus ([S II]/H α) = -1.44 suggests that it might harbor a weak active galactic nucleus (AGN). The source is extremely bright in the mid-infrared WISE bands, so it may be a LIRG/ULIRG or highly obscured Type 2 AGN.

Narrow emission lines were also detected in the spectra of 2MASS J02155016+4806200 ($l \sim 137.2$ $b \sim -12.4$, lines: H β , [O III]) and WISEA J185756.83+321653.3 ($l \sim 62.8$ $b \sim 12.8$, lines: [O III], H α , [N II], [S II]), indicating these are galaxies at $z = 0.090 \pm 0.002$ and 0.079 ± 0.002 , respectively.

2MASS J00450929+4202393 and 2MASS J00471445+4202098 (at 53.8 and 68.3 from the M31 center, respectively) show stellar-like spectra. After a comparison with templates we assign to them spectral types M3 $\pm$ 1 and M4 $\pm$ 2. Both spectra show weak Balmer emission lines, suggesting some chromospheric activity. The second spectrum also shows some continuum in the blue, but given the low signal-to-noise we cannot determine its origin. It may be due to a contamination from a nearby early-type star. 2MASS J00450929+4202393 has been classified as a star before (e.g., Mould et al. 2004; Jacoby et al. 2013).

Summarizing, we obtained low-resolution spectra of six quasar candidates behind M31 and in the direction of the Milky Way anticenter. One is a bona fide quasar, three are narrow emission line galaxies (although they still may harbor Type 2 AGNs) and two are probably stars belonging to M31. We report also the non-quasars to prevent other observers from spending telescope time on them.

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Facilities: Asiago:Galileo - , Asiago:Copernico. -

Footnotes

11 <https://opticon-schools.nbi.ku.dk/observing-schools/neon-observing-school-2018/>

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