Searching for the origin of double-peaked broad emission lines in a merging galaxy with EVN

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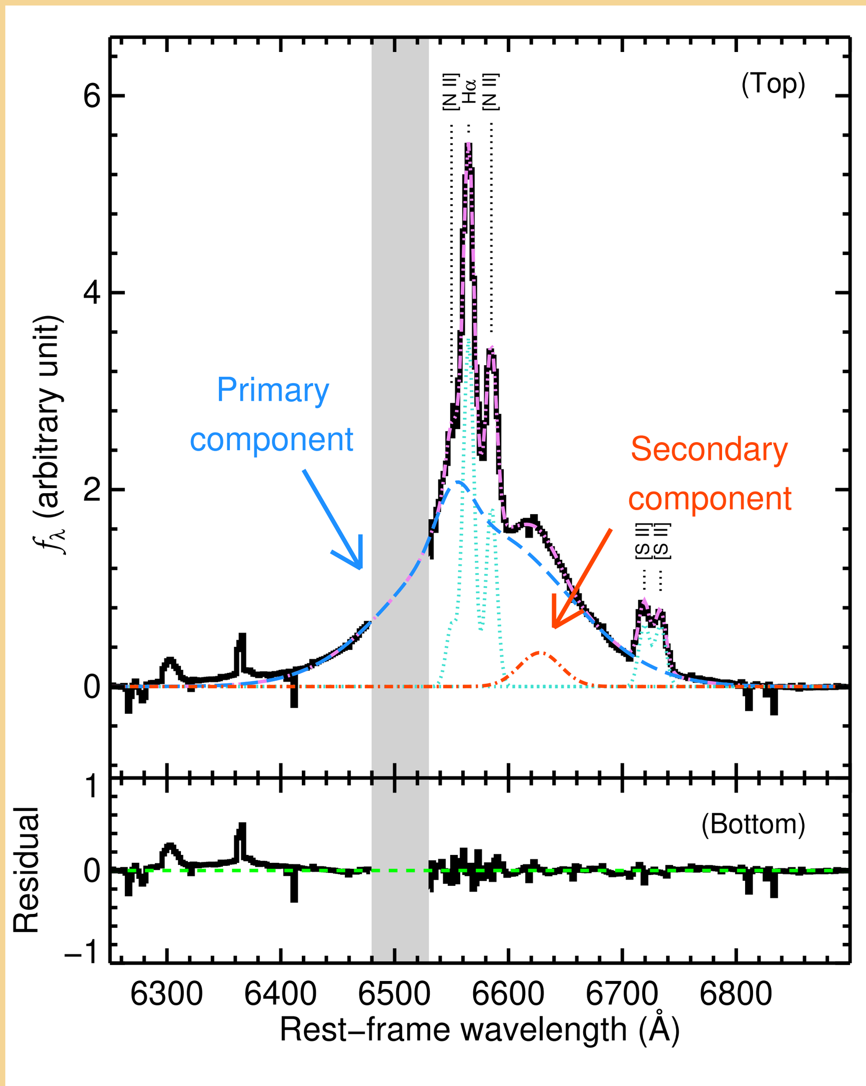
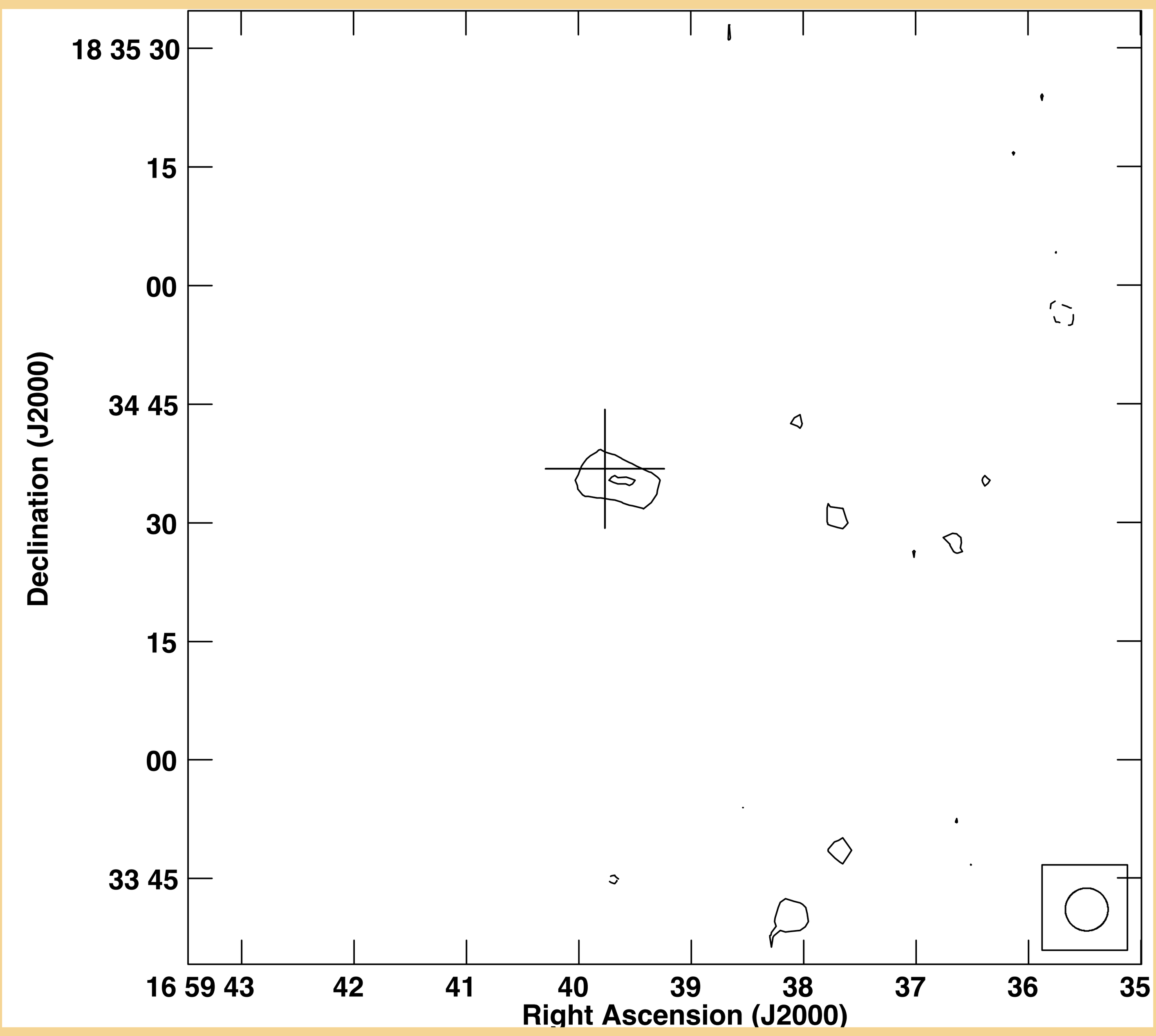
Context. The current cosmological structure formation models predict that galaxies grow through frequent mergers. During these events, activity in the nuclei of the merging galaxies can be triggered. Numerical simulations (e.g. Van Wassenhove et al. 2012; Capelo et al. 2015) suggest that simultaneous activity is mostly expected at the late phases of mergers, at or below 10 kpc-scale separations. If the merging supermassive black holes (SMBHs) have unequal mass or are asymmetric with respect to their spins, the emitted gravitational waves are also asymmetric, which can result in a recoil (Blecha et al. 2011). Such recoil events can reduce but also extend the AGN lifetime depending on the parameters of the merging system. Thus centrally offset AGNs might be explained as originating from a recoiling SMBH.

One way to identify dual AGN candidates is by detecting **double-peaked emission lines** in their spectra. If these are broad spectral lines, it may indicate the existence of two broad line regions associated with two AGNs. Currently, only a few dual AGNs are known which could be resolved and thus their duality could be directly confirmed. VLBI offers the highest angular resolution thus theoretically providing the best tool to resolve dual AGNs, however its usefulness is limited to a small fraction of potential sources since only ~10% of AGNs are radio-emitting (Ivezić et al. 2002).



Kim et al. (2020) identified an AGN with double-peaked broad emission lines in a host galaxy, 2MASS J165939.7+183435 (hereafter J1659+1834) showing merger features in optical regime at redshift z~0.17.
Left: Double-peaked broad line, and narrow-line of Hα, and narrow lines of [NII] and [SII] in the integrated spectrum of **J1659+1834 obtained by Kim et al. (2020)** using the GMOS Integral Field Unit on the Gemini North telescope. The black hole masses derived from the Hα lines are $10^{8.92\pm0.06}$ $M_\odot$ and $10^{7.13\pm0.06}$ $M_\odot$



1.4-GHz FIRST image of J1659+1834. Peak intensity is 1.17 mJy/beam, the positive contours are drawn at 0.4 mJy/beam (3 times the image noise level) and 0.8 mJy/beam. The restoring beam size is 5.4” x 5.4” and is shown in the bottom right corner. Cross denotes the Gaia DR2 position (Brown et al. 2018).

Radio emission from J1659+1834: The Faint Images of the Radio Sky at Twenty-Centimeters (FIRST, White et al. 1997) survey detected a radio source at ~2.2” to the southwest from the optical/infrared position (measured by the Sloan Digital Sky Survey, Gaia, and 2MASS) of J1659+1834. The radio source has a flux density of (2.56±0.15) mJy (see image to the left), corresponding to a radio power of 2×10^{22} W/Hz.
Observation. We initiated 1.7-GHz European VLBI Network observation of J1659+1834. The observation took place on 2021.03.21 with an on-source integration times of 6 hours. From the 19 participating antennas 18 provided data. **Results.** We did not detect compact radio emission down to an image noise level of 50 μJy/beam (6σ).
Conclusion. Our EVN non-detection cannot completely rule out the existence of a radio-AGN in the system. The extended radio emission detected by FIRST can be explained by star formation enhanced due to the merger event revealed by the optical images or by large-scale radio emission from the lobe(s) of a radio-AGN, or from the combination of both. If the FIRST-detected radio emission solely comes from star formation, it implies a star formation rate of ~11 $M_\odot$/year (Hopkins et al. 2003).

References:

Blecha at al. 2011, MNRAS, **412**, 2154
Brown et al. 2018, A&A, **616**, A1
Capelo et al. 2015, MNRAS, **447**, 2123
Hopkins et al. 2003, ApJ, **599**, 971
Ivezić et al. 2002, AJ, **124**, 2364
Kim et al. 2020, ApJ, **894**, 126
Van Wassenhove et al. 2012, ApJ, **748**, L7
White et al. 1997, ApJ, **475**, 479

The EVN is a joint facility of European, Chinese, South African, and other radio astronomy institutes funded by their national research councils. Scientific results from data presented here are derived from the following EVN project code: EG112. e-VLBI research infrastructure in Europe is supported by the European Union’s Seventh Framework Programme (FP7/2007-2013) under grant agreement number RI-261525 NEXPReS. The research leading to these results has received funding from the European Commission Horizon 2020 Research and Innovation Programme under grant agreement No. 730562 (RadioNet). We thank the Hungarian National Research, Development and Innovation Office (OTKA K134213, 2018-2.1.14-TÉT-CN-2018-00001) for support.