Very Long Baseline Array Imaging of Parsec-scale Jet Structures in Radio-loud Narrow-line Seyfert 1 Galaxies

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(Submitted on 26 Jul 2011)

We conducted very long baseline interferometry (VLBI) observations of five radio-loud narrow-line Seyfert 1 (NLS1) galaxies in milliarcsecond resolutions at 1.7 GHz (18 cm) using the Very Long Baseline Array (VLBA). Significant parsec-scale structures were revealed for three out of the five sources with high brightness temperature by direct imaging; this is convincing evidence for nonthermal jets. FBQS J1644+2619 with an inverted spectrum showed a prominent one-sided linear structure, indicating Doppler beaming with an intrinsic jet speed of >0.74c. FBQS J1629+4007, also with an inverted spectrum, showed rapid flux variability, indicating Doppler beaming with an intrinsic jet speed of >0.88c. Thus, we found convincing evidence that these two NLS1s can generate at least mildly or highly relativistic jets, which may make them apparently radio loud even if they are intrinsically radio quiet. On the other hand, the other three NLS1s had steep spectra and two of them showed significantly diffuse pc-scale structures, which were unlikely to be strongly beamed. Thus, some NLS1s have the ability to generate jets strong enough to make them intrinsically radio loud without Doppler beaming. NLS1s as a class show a number of extreme properties and radio-loud ones are very rare. We build on these radio results to understand that the central engines of radio-loud NLS1s are essentially the same as that of other radio-loud AGNs in terms of the formation of nonthermal jets.

Comments:	12 pages, 1 figure, accepted for publication in ApJ
Subjects:	**Cosmology and Extragalactic Astrophysics (astro-ph.CO)**; High Energy Astrophysical Phenomena (astro-ph.HE)
Cite as:	**arXiv:1107.5117 [astro-ph.CO]** (or **arXiv:1107.5117v1 [astro-ph.CO]** for this version)

Submission history

From: Akihiro Doi [view email]

[v1] Tue, 26 Jul 2011 04:59:23 GMT (730kb)

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