Tracing the High Energy Emission of the Radio Loud Quasar RGB J1512+020A

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Abstract: We present a multiwavelength study of the core and relativistic jet of the radio loud quasar RGB J1512+020A (z=0.22). A ~3 ksec *Chandra* observation has revealed a 13'' (~46 kpc) extended X-ray jet. The X-ray jet is one of the fewest and brightest associated with a low-z radio quasar. We resolve the jet X-ray emission in the direction perpendicular to its main axis. This provides us with a rare opportunity to probe the jet structure. The broadband core spectrum ha contributions from the central quasar, a blazar component, responsible for the γ-ray emission detected by *Fermi*, and a host galaxy component. We model the non-thermal blazar spectral energy distribution (SED) and constrain the total jet power. The jet power inferred from the blazar SED modeling is in agreement with the values obtained from the total radio power, pointing to a jet that efficiently carries its power up to kiloparsec scales.

X-ray Jet:

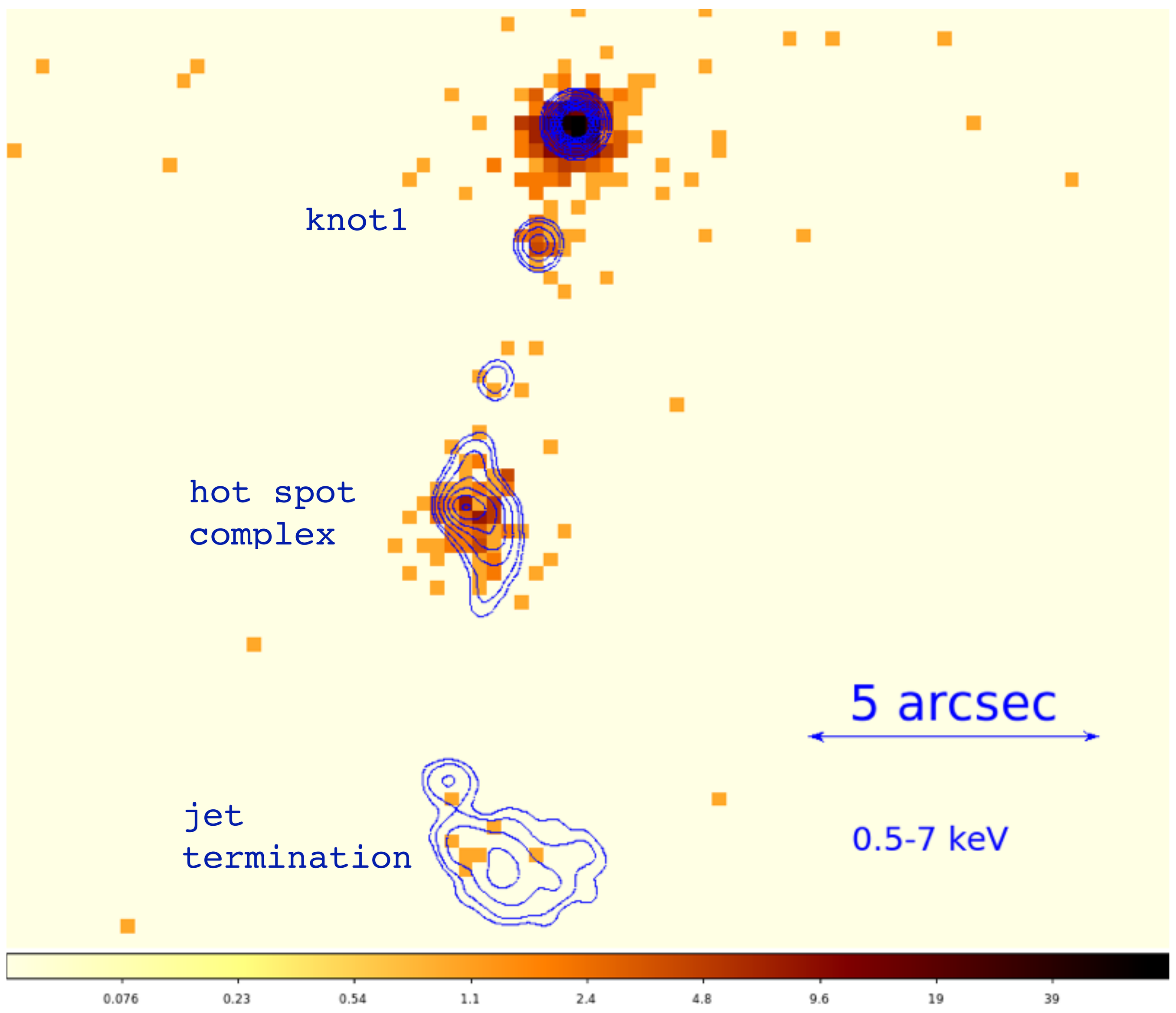

Fig.1: *Chandra* 0.5-7 keV ACIS-S image and overlaid VLA 4.9 GHz contours of RGB J1512+020A. The jet X-ray emission is dominated by the central feature (hot spot complex).

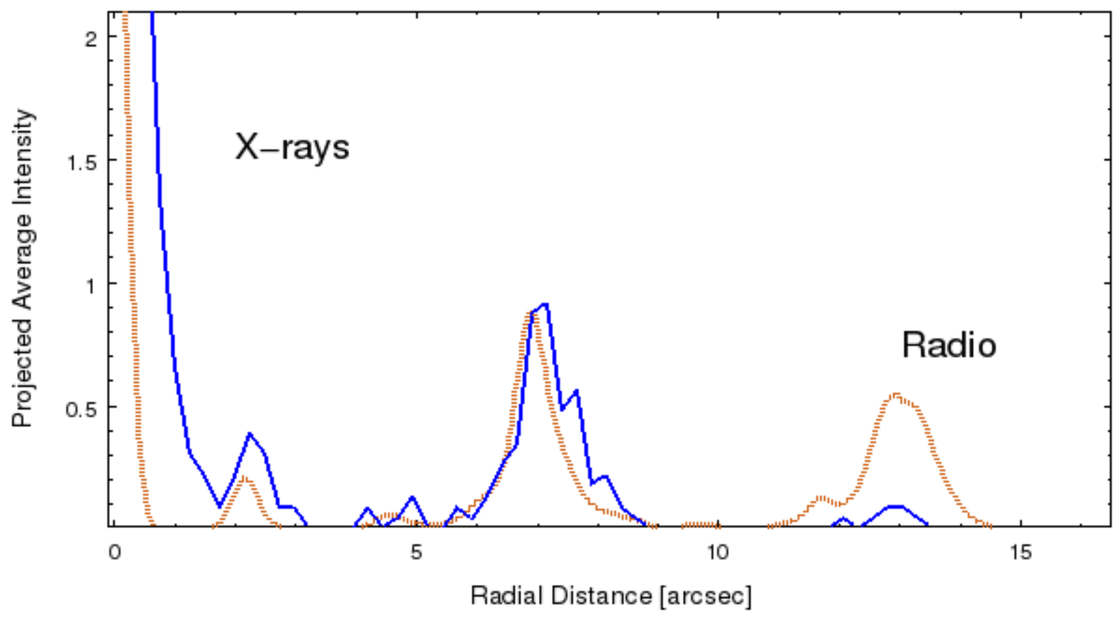

Fig.2: radio (4.9 GHz) and X-ray (0.5-7 keV) brightness profiles along the jet in arbitrary units: the main radio features are traced by the X-ray emission.

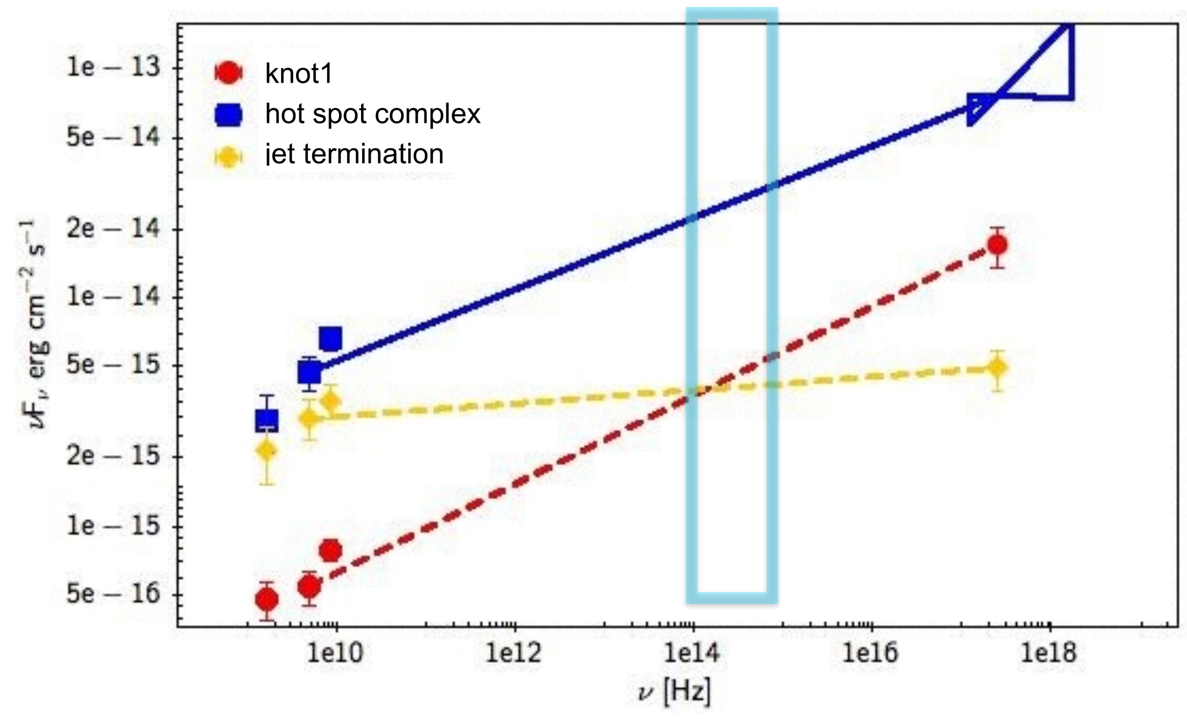

Fig. 3: radio to X-ray SED of the jet main features. The dashed lines show the radio to X-ray flux interpolation. The cyan empty rectangle highlights the optical-UV window.

- Bright X-ray jet ($F_{0.3\text{-}7keV}=3.22\times10^{-13}$ erg cm^{-2} s^{-1}) with a large jet to core X-ray flux ratio (0.2) compared with X-ray quasar jets (≲0.1, [1,2]);
- the 0.2-3 keV emission of the hot spot complex is extended (Fig. 1) in the direction along (5'') and perpendicular to (~3.4'') the jet main axis. There might also be the contribution of thermal X-ray emission produced by jet-medium interactions.
- Nature of the X-ray emission: the radio and X-ray brightness profiles (Fig. 2) and the broad band SED (Fig. 3) are similar to powerful Fanaroff Riley type II jets but observations in the IR to optical window are necessary to (1) rule out a single synchrotron component; and (2) determine the location and intensity of the synchrotron peak and constrain the origin of the X-ray emission (IC/CMB, 2nd synchrotron component).

Core SED:

Blazar SED modeling:

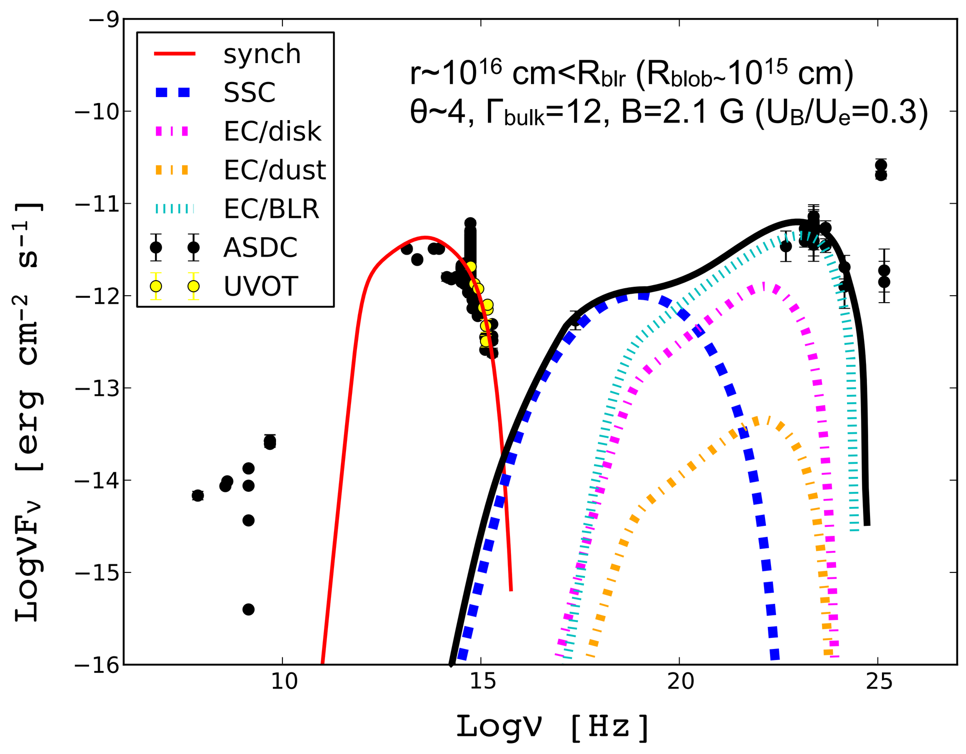

Fig. 4: Observed SED and model of the blazar emission with a one-zone synchrotron IC model. The data in the γ-ray band are the 6 year averaged *Fermi*-LAT flux.

IR-UV SED:

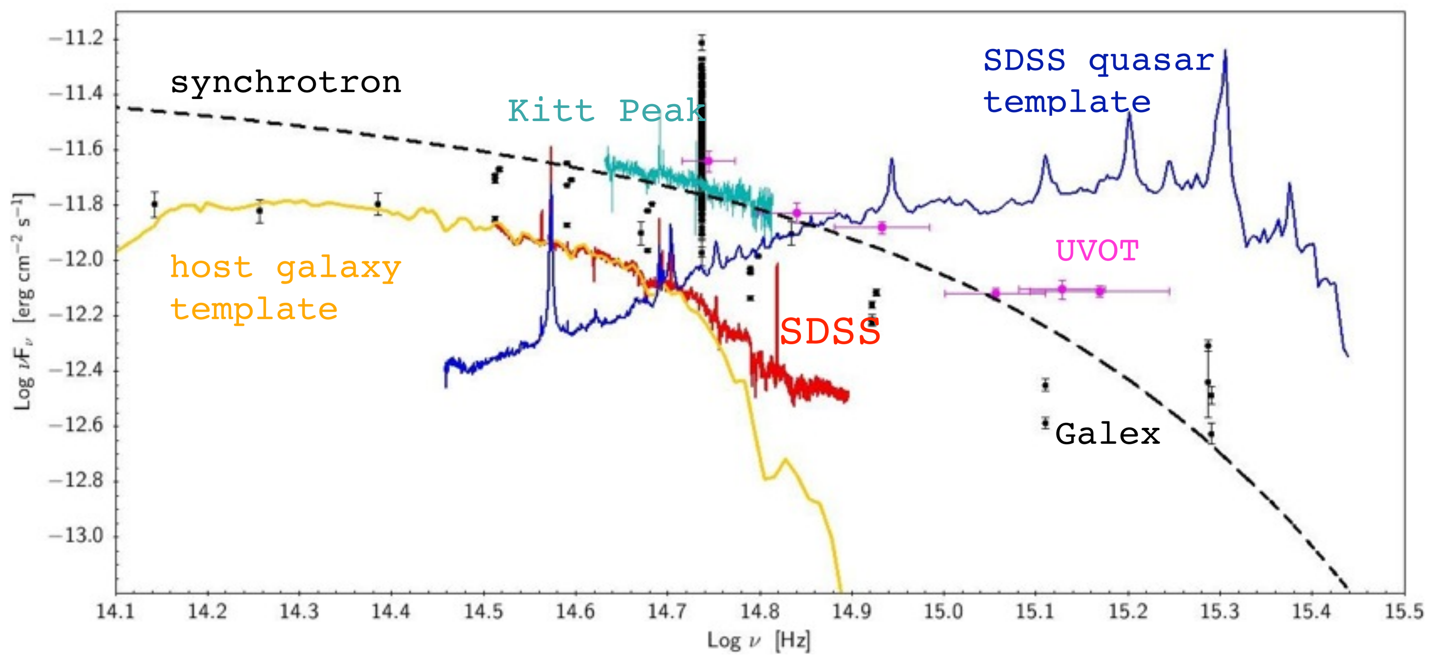

Fig. 5: IR to UV SED of the RGB J1512+020A core: the host galaxy emission is visible in the IR [4], the quasar emission is modelled with the template of [5]. The synchrotron curve is from the model in Fig. 4.

- Jet kinetic power ($L_{jet,kin}$): $L_{jet,kin}$ inferred from the modeling of the blazar emission is in the range 10^{44}-10^{46} erg s^{-1} and consistent with the $L_{jet,kin}$ estimated from the total radio power ($L_{jet,kin}$~10^{45} erg s^{-1} [3]), pointing to limited energy dissipation up to kilo parsec scales;

- the disk emission is weak in UV when compared to typical quasars: low/high power intermediate source? (see also [6]);
- a disk bolometric luminosity of L_{disk}~7×10^{43} erg s^{-1} is estimated from the broad line luminosity, L_{BLR}, (see [7]) assuming a L_{BLR} to L_{disk} ratio of 0.1.

In RGB J1512+020A the jet kinetic power appears at least comparable with or larger than the disk power in line with recent findings (see [8]).

Summary: we discovered a bright X-ray jet in the radio quasar RGB J1512+020A. The X-ray emission is transversally resolved and makes this source an ideal target to probe the jet inner structure and its interaction with the environment. The kiloparsec scale jet characteristics are similar to those of powerful FR II jets, however the disk luminosity and UV emission are unusually low for a quasar suggesting that RGB J1512+020A could be intermediate between low power and high power sources (see e.g. [9]).

References: [1] Marshall et al. 2011, ApJS, 193, 15; [2] Massaro et al. 2011, ApJS, 197,24; [3] Willott et al. 1999, MNRAS, 309, 1017; [4] Mannucci et al. 2001, MNRAS, 326, 745; [5] Vanden Berk et al. 2001, AJ, 122, 1017 [6] Sbarrato et al. 2012, MNRAS, 421, 1764; [7] Celotti et al. 1997, MNRAS, 286, 415; [8] Ghisellini et al. 2014, Nature, 515, 376; [9] Sambruna et al. 2007, ApJ, 670, 74.