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The Jet of the BL Lac Object PKS 0521-365 in the mm-Band: ALMA Observations

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Abstract. BL Lac objects are low-power active nuclei exhibiting a variety of peculiar properties caused by the presence of a relativistic jet and orientation effects. Since the jet is closely aligned with the line of sight, it is very difficult to observe unless the angular resolution is high. At millimeter wavelength in particular, until the advent of ALMA, information on the jet emission was lacking from the previous facilities. Here we report our preliminary results on the millimeter emission of PKS 0521-365, one of the most interesting BL Lac objects of the southern sky, using ALMA multifrequency archival data.

1. The BL Lac object PKS 0521-365

This is a nearby (z = 0.0554) radio-loud object and bright FERMI source, exhibiting a variety of nuclear and extranuclear phenomena (Falomo et al. 2009). It is one of the three known BL Lac objects showing a kiloparsec-scale jet well resolved at all bands (Liuzzo et al. 2011). As showed in Fig.1, a one-side radio jet extends in N-W side up to 7″, with the presence of many knots that are also detected from optical to X–rays (Falomo et al. 2009). An hotspot is also detected in all bands at ∼ 8 ″from the nucleus in the southeast direction. At low frequency, the arcsecond-scale radio structure is dominated by an extended lobe.

The overall energy distribution of PKS 0521-365 is consistent with a jet oriented at about 30 degrees with respect to the line of sight. This is also in agreement with the absence of superluminal motion in the parsec–scale jet (Falomo et al. 2009 and references therein).

In the millimeter bands, no information on the extended structures of this object are available from literature. With the advent of the high quality Atacama Large Millimeter/submillimeter Array (ALMA) data, a detailed study of the jet and hotpot of this target (as well of the whole class of BL Lac objects and quasars) is now possible.

2. ALMA data: preliminary results

For PKS 0521-365, ALMA multiepoch and multifrequency data are available from the public archive as it is used as bandpass calibrator in many projects. We started analyzing one epoch in band 3, 6, 7, and 9. In the following, we present our preliminary results. More detailed, quantitative fundings and future perspectives of this work will be discussed in Liuzzo et al. in preparation.

- **Morphology**: Hotspot and jet are detected in the mm wavelengths (e.g. Fig.1), at least up to 320 GHz, with similar structures from optical to X–rays.

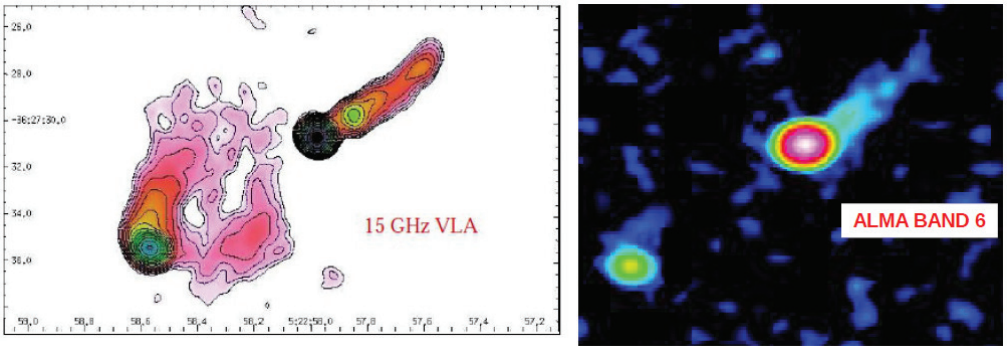

Figure 1. VLA at 15 GHz (*left panel*) and ALMA band 6 (*right panel*) archival images of the BL Lac object PKS 0521-365.

- **Spectral energy distribution (SED)**: Thanks to the multi-ν (HST NTT, VLT, MAD, Chandra, VLA) available data, we constructed the SED for each source components. Accordingly with the expectations, the jet knots and hotspot are dominated by a single synchrotron component, while in the nucleus an inverse Compton component is present at high energy.

- **Molecular gas content (M(H2))**: In literature, the CO emission line was investigated in only 3 BL Lacs (Fumagalli et al. 2012). In the case of PKS 0521-365, the band 3 data contain also the CO(1–0) line frequency (rest frame $\sim$ 109,2 GHz). No CO–line emission is however detected. We derived upper limits: CO luminosity L(CO)$\leq$2.8$\times$ 10^5 Km s^{-1}pc^{-2} and M(H$_2$))$\leq$1.1$\times$ 10^6M$_{Sun}$, assuming α= 4M$_{Sun}$ K Km s^{-1}pc^{-2}. These estimates appear lower by a factor of 3 than the typical values for quasars, being more similar to low-z radiogalaxy (e.g. M87). This could suggest that the host galaxies of the BL Lacs and quasars are not drawn from the same parent population. High quality observations are needed to increase the statistic and this could be done now thanks to the advent of ALMA.

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