Effects of the turbulent ISM on radio observations of quasars

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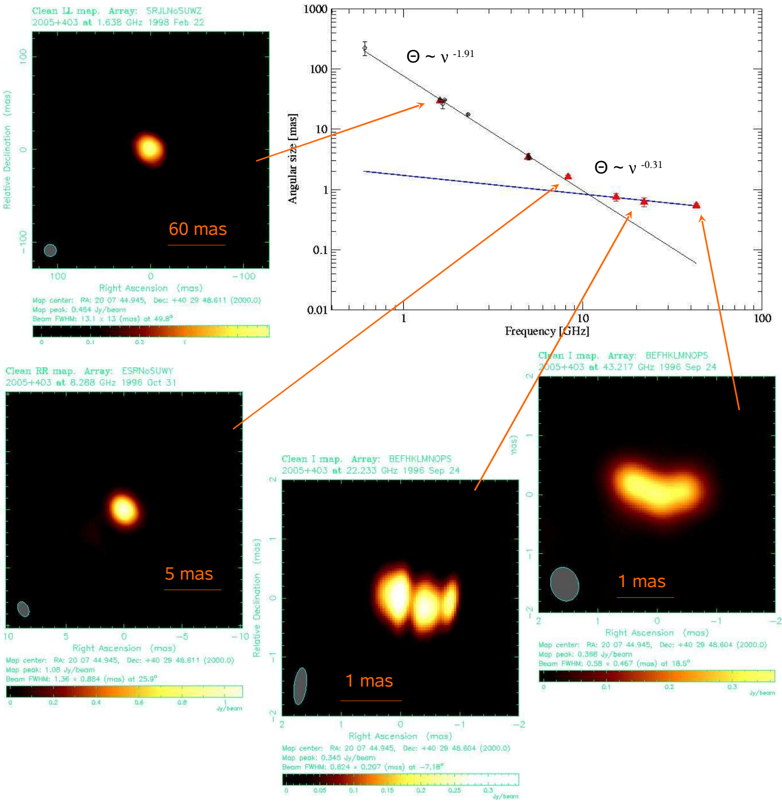
The scatter-broadened quasar B2005+403

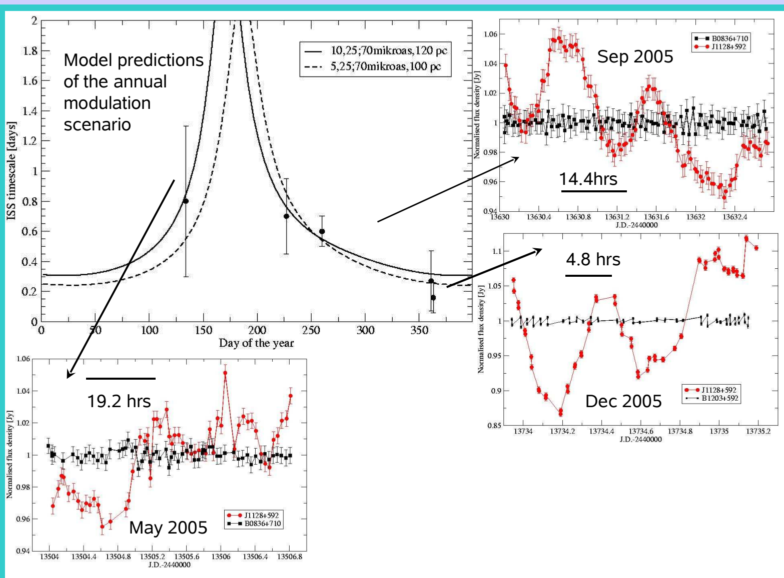
B2005+403 is a quasar at a redshift of z=1.736 (Boksenberg et al., 1991); its line of sight passes through the heavily scattered Cygnus region (l=76.82°, b=4.29°). Fey et al. (1989) and Desai & Fey(2001) studied several sources, including B2005+403, towards this region.They found that B2005+403 is heavily scatter-broadened.
We complemented their measurements with the results of multifrequency VLBI observations of B2005+403. Some example images of these obseravtions are shown here.

The plot on the right hand side summarizes our results. The apparent size is displayed versus observing frequency. Black circles denote data from the literature, red triangles are from our observations. The black line is a power law fit to the data up to 8 GHz. Blue line is a power law fit to the three highest frequency measurements (15 GHz, 22 GHz, and 43 GHz). In B2005+403 scattering dominates the source image at least up to 8 GHz. However at higher frequencies, the intrinsic structure shines through. Thus, the blue line represents an upper limit on the source structure. With this fit, we were able to calculate the intrinsic source size at frequencies, where scattering dominates the source image, and from this estimate the scattering disk size: θ_{disk}= 77 mas at 1 GHz. From this the scattering measure (SM), the line of sight integral of the electron density flutuations, can be calculated: SM=0.41 $m^{-20/3}$ kpc. This is consistent with previous calculations.

Interstellar scattering causes broadening of the image and predicts that the angular size scales as $\nu^{-2.2}$ if the turbulence is Kolomgorov. However, in B2005+403, the obtained exponent of the power law is -1.91. An exponent close to -2 can signify that either the turbulence is non-Kolmogorov, or that the inner scale of the fluctuations is larger than the largest baseline used in the observation. In the latter case, the lower limit for the inner scale is 8100 km. This is higher than the values reported earlier by Fey et al. (1989) and Wilkinson et al. (1994) for the Cygnus region.



J1128+592, a new IDV source with hints of annual modulation



1. IntraDay Variaibility – in general

- Timescales of the variations are typically ~2 days or less.
- Peak-to-peak varitations can be as high as couple of percent in total flux density, and ~20-100% in polarized intensity.
- 25% of flat spectrum extragalactic radio sources show IDV phenomenon.
- Usually the variations are more pronounced at lower frequencies.
- If intrinsic, the light-travel time argument implies brightness temperatures far above the inverse compton limit, usually in the range of 10^{16} -10^{18} K. These can be explained with Doppler boosting, with boosting factors of 100-1000; not yet observed in VLBI images.
- Extrinsic explanation: IDV is caused by propagation effect in the turbulent ISM of the Milky Way. Scattering of radio waves of a distant quasar can be observed as flux density variations if the screen and the observer move with respect to each other. As the Earth orbits around the Sun the relative velocity changes troughout the year, causing slow down and speeding up of the variations in different seasons. Such seasonal cycles are one of the strongest arguments for extrinisic explanation of IDV. Annual modulation was observed in four of sources: J1819+3845 (Dennett-Thrope & de Bruyn, 2003), PKS1257+326 (Bignall et al., 2003), PKS 1519-273 (Jauncey et al., 2003) and B0954+658 (T. Krichbaum priv. comm.)

2. J1128+592 – a new IDV source

J1128+592 is a compact quasar at a redshift of z=1.799 (Britzen et al., 2006 in prep.), with mean flux density of ~0.7 Jy at 5GHz. In December 2004 an observing campaign with the Effelsberg 100 meter radio telescope revealed fast variations with high (~20%) peak-to-peak variations in its total flux density at 5 GHz. Then the source was included in several IDV observations through 2005. J1128+592 showed a slow down in May and in August 2005, slight decreasing in the timescale of the varitions in September and again fast variability in December 2005. The above pictures show the lightcurve of J1128+592 (red circles and lines) with secondary calibrators (black squares and lines) for comparision at different epochs. The estimations of the variability timescales are displayed in every lightcurve. If these variations were intrinsic, the implied birghtness temperatures would be ~10^{18} K and thus would require Doppler boosting factors of several hundreds to reach to inverse Compton limit in the source frame.

The changes in the timescale suggest an annual modulation scenario. The two model calculations are shown together with the estimated timescales at different time of the year. The scintillating source size is assumed to be 70µas. The solid line represents a scattering screen at 120 pc and LSR velocities of v_{RA}=10 km/s and v_{δ}=25 km/s. The dashed line represents a model, where the scattering screen distance is 100 pc and its LSR velocities are also slightly different v_{RA}=5 km/s and v_{δ}=25 km/s.

Future observations can confirm the annaul modulation scenario and better constrain the model parameters, thus broadening our knowledge on the LISM and reveal details on the background source characteristics as well.

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