Astrophysical Phenomena Revealed by Space VLBI
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Instantaneous 1–22 GHz Spectra of 214 VSOP Survey Sources

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Abstract

We present selected results of our monitoring, which form the basis of a ground spectra support for a space VLBI survey in the framework of the VSOP work team project. The 214 sources were selected from the HALCA continuum survey list, containing 230 sources with declinations north of $-30°$ (Fomalont et al., these proceedings). Every 1–22 GHz spectrum was measured with the RATAN–600 radio telescope at six wavelengths of 1.4, 2.7, 3.9, 7.7, 13, and 31 cm, over a period of a few minutes (ten minutes or more near the pole). Almost all sources are suggested to have continuous jets at milliarcsecond scales. This conclusion is supported by the analysis of the 214 individual spectra, their mean normalized statistical shape in the local frame, and the long-term variable spectra of 23 objects. Model and statistical analysis suggest the common physical origin of various radio sources in the studied sample.

1 Results of Observations

We carried out three following sets of six frequency 1–22 GHz spectra observations of the HALCA survey sources: from 1 to 22 December, 1997 (sources with declinations $-30° < \delta < +43°$), from 11 to 25 July, 1998, and from 15 September to 1 October, 1998 (sources with $\delta > +49°$). We used the 600 meter ring radio telescope RATAN–600 (Korolkov and Parijskij 1979; Parijskij 1993), located at the North Caucasus. The parameters of broad band receivers, the RATAN–600 beam widths, the details of the observational procedure, data processing, and calibration, as well as the spectra of 170 of 214 VSOP/HALCA sources are recently published in Kovalev et al. (1999). The spectra of the other 44 of 214 sources from our list are presented in Fig. 2 (flux density calibration is preliminary for the sources with $\delta > +49°$). In addition, the results of the long-term spectra monitoring program (Kovalev 1997) for the

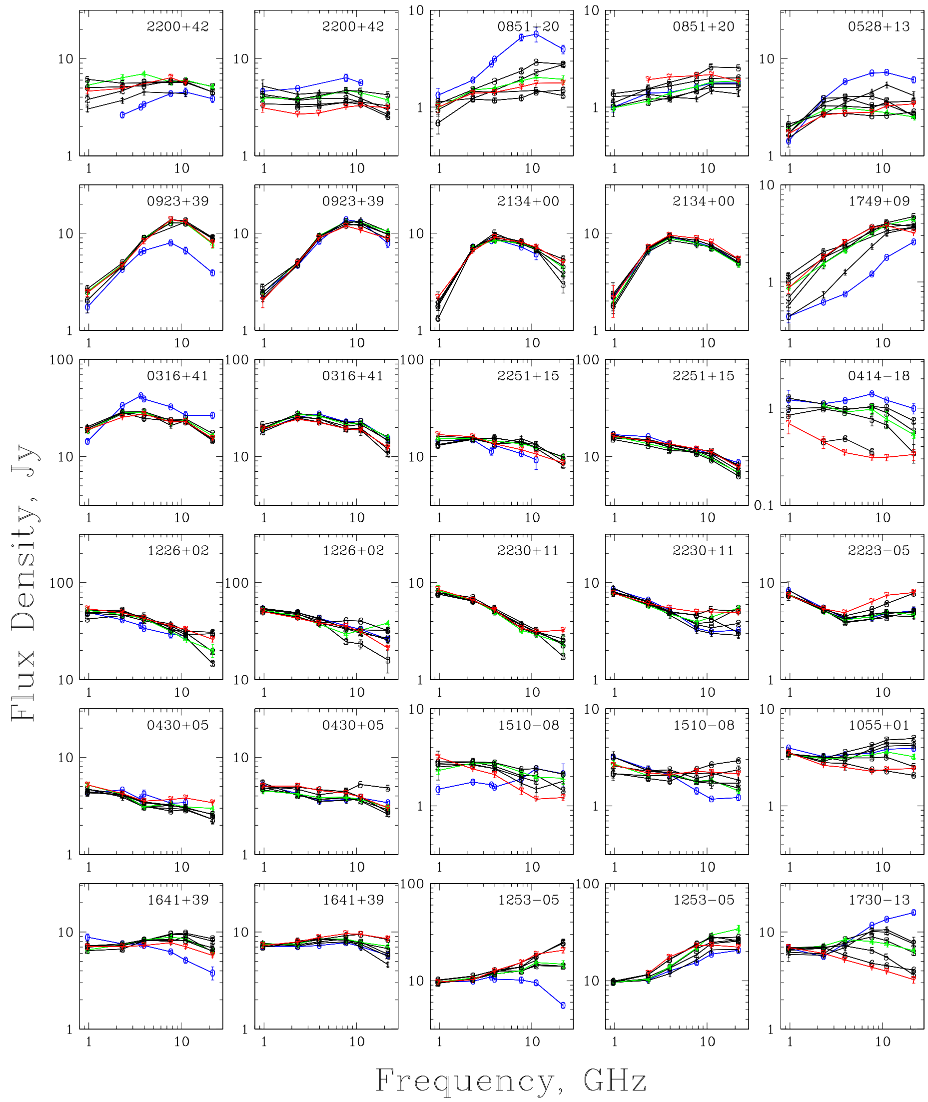

Figure 1: Multi-epoch instantaneous spectra for 18 well-known strong variable sources. Epochs for each of the columns 1 and 3 from the left: 1989, November; 1995, August, October, December; 1996, March, June, July, December (eight epochs, labeled 0–7, respectively). Epochs for each of the columns 2, 4 and 5: 1996, December; 1997, March, June, September, December; 1998, March; 1999, April, September (eight epochs, labeled 0–7).

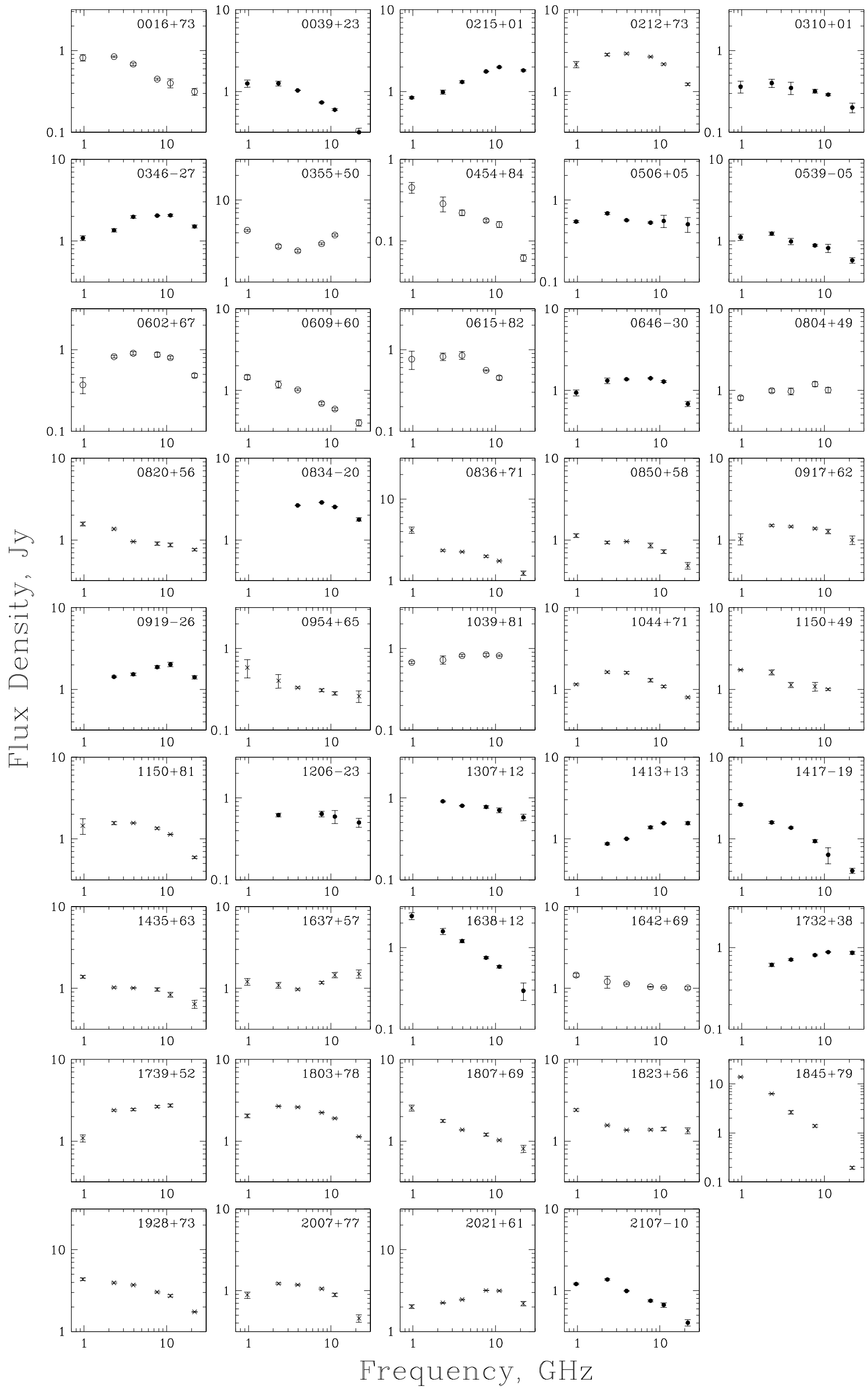

Figure 2: One epoch spectra of 44 sources in 1997–1998.

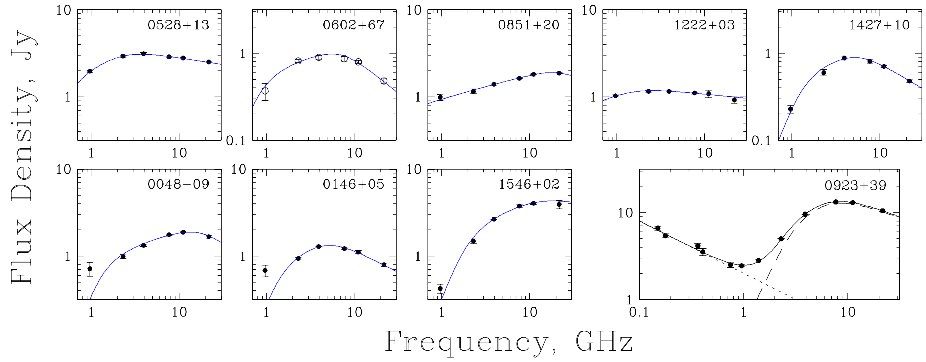

Figure 3: Examples of fitting (solid lines) by the Hedgehog jet model. χ^2-criterion is satisfied at 0.05 significance level. Only for 0923+39 the low frequency component of the spectrum is modeled. Additional low frequency data for 0923+39 are from CATS data base.

18 strong HALCA sources in 1989, 1995–1999 (up to 15 epochs) are presented in Fig. 1. The IAU B1950 names of the sources are adopted.

2 Results of Analysis

The jet model analysis of the spectra is similar to the one by Kovalev and Larionov (1994), Kovalev and Kovalev (1997). It is based on the Hedgehog jet model of an active galactic nucleus with quasi radial magnetic field, suggested by Kardashev (1969) and developed by Kovalev and Mikhailutsa (1980). The one epoch spectra for all observed HALCA sources have been analyzed (see examples in Fig. 3). The analysis allows distinguishing a broad band emission of a continuous jet with quasi-stationary ejection at milliarcsecond scales for almost all objects of the sample. In addition, a second component at lower frequencies with a steep spectrum is visible in a part of the sources (e.g. lower boxes in Fig. 3). The second component can be explained by the emission of an extended magnetized envelope/lobe which accumulates the relativistic particles from the jet.

Using the calculated distributions of 214 sources over the red shift and the two points spectral indices (Fig. 4), we obtain the mean normalized statistical spectrum in the local frame. The mean spectral shape can also be interpreted by the combined emission from the jet and the envelope/lobe (Fig. 5).

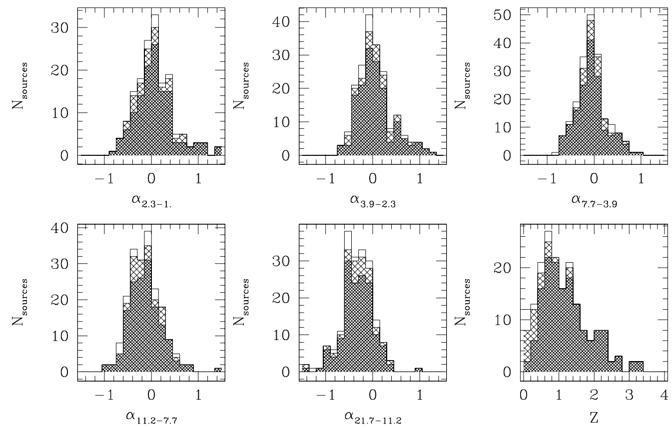

Figure 4: The distributions of 214 sources over the two-point spectral indices $\alpha_{\nu_2-\nu_1}$ and the red shift z (strong hatched for quasars, hatched for BL Lacs, open for galaxies).

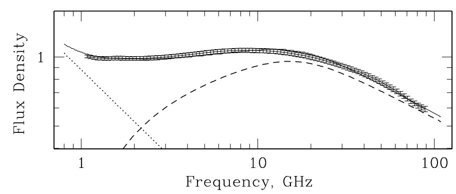

Figure 5: Mean statistical normalized spectrum with errors for the full sample in the local frame and the model fit. The thin solid line curve is the sum of dashed line curves for two spectral components, similar to 0923+39 model in Fig. 3.

The strong long term variability of the instantaneous spectra, which is seen in Fig. 1, can be explained in the same jet model by the variability of a flow of relativistic particles ejecting from an active core. Evolution of multi-epoch instantaneous spectra demonstrates such variability, at least, for the following 23 objects: 0316+41, 0430+05, 0851+20, 0923+39, 1226+02, 1253−05, 1510−08, 1641+39, 2134+00, 2200+42, 2251+15 (for up to 20 years), and for 0458−02, 0414−18, 0528+13, 1055+01, 1124−18, 1156+29, 1730−13, 1749+09, 2209+23, 2223−05, 2230+11, 2355−10 (for up to 10 years).

In the framework of our model, all strong VLBI structure components are interpreted as the maximums of a quasi-stationary or evolving distribution of the brightness along a continuous jet, rather than as a set of separate clouds of a structure. It is interesting to note that the radio emission of an active core is not visible in these spectra. On this reason, a bright region in VLBI maps, which is sometimes interpreted as a strong compact core, may actually be the local brightest part of a jet (not a real active core of a source). If this region is the real active core and its flux density is greater than 3σ level or (5–10)% of the total flux density, the spectrum of the core would have to be well recognized as an additional spectral component.

Presented model calculations of the spectra yield the same results for both straight line jets and a class of twisted jets, which is characterized by a constant angle between a curved axis of a jet and the direction to an observer. Thus, the VLBI images with high resolution are required also to decide between two these types of the jet and predictions of other models.

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