Unusual GPS quasar 0858–279

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Properties of the GPS quasar 0858–279

We monitor at RATAN-600 more than 600 extragalactic objects north of declination $-30°$ (Kovalev et al. 1999). We have identified and analyzed variability properties of a subsample of objects which permanently show gigahertz-peaked spectra. One of the GPS objects with a high amplitude of variability was found to be the high redshift quasar ($z = 2.152$) 0858–279 (see Figure 1) which shows GPS-like spectral shape at all observing epochs. This finding is supported by ATCA monitoring results (Edwards & Tingay 2004). They have shown that the variability index for this object is the highest one among the GPS sample investigated (we do not consider 1519–273 which is known to be a strong IDV and NGC 1052 which is not a "true" GPS). In general, 90% of "true" GPS sources (which possess a GPS spectrum at any observing epoch) are not variable within error bars. And the rest 10% has quite low amplitude of variability.

This objects is reported by Ricci et al. (2004) to have 106 ± 7 mJy of linearly polarized total flux density at 18.5 GHz which makes fractional polarization $7.1 \pm 0.5\%$. Such high degree of linear polarization is quite unusual for a flat spectrum radio source and even more unusual for a GPS one.

We have used data from the VLBA Calibrator Search program to analyze the milliarcsecond scale structure of the quasar. It was found to be significantly resolved. The dominating component is 1.3 mas at 4cm and 12 mas at 13 cm in size.

In opposite, the time scale of the radio variability observed is of the order of several months which gives an estimation of the size of the varying component from light-travel time arguments in the absence of coherence (Marscher et al. 1979) to be $< 20\delta\,\mu$as for the redshift of 2.1 where δ is the unknown Doppler factor. The amplitude of the radio variability observed is of the order of 1 Jy.

First results of the current study

We have observed the GPS quasar simultaneously in six frequency bands (L, S, C, X, U, K) with the NRAO VLBA array. Results of the total intensity and polarization imaging are presented in Figure 2, spectral index image for the highest observing frequency range between 15 and 22 GHz — in Figure 3. We have found the following.

1. It is confirmed that the structure is heavily resolved at all observing frequencies. It becomes more compact at higher frequencies while the the dominating component of the emission becomes optically thin.
2. Spectral index image for 11–22 GHz shows a compact component with inverted spectrum ($\alpha \sim +1$) which is most probably a core region while the dominating component with $\alpha \sim -1$ must be a jet region of the quasar. The high resolution high frequency observations have finally revealed a typical core-jet structure at mas scale for this quasar.
3. Electric vectors of linear polarization are parallel to the inner jet direction at high radio frequencies and rotate by about 90 degrees from 15 to 8-5 GHz. In the same time, the degree of linear polarization drops from 10-20% at high frequencies to about or less than 4% at 8 GHz and below it. This is consistent with and suggests the synchrotron radiation with self-absorption from a blob with highly ordered magnetic field. Magnetic field lines are therefore perpendicular to the inner jet direction.
4. We have measured the true angular size of the dominating component at frequencies above the synchrotron self-absorption turnover frequency which appeared to be 0.5–0.6 mas. The observed strong variability of the total flux density with a characteristic time scale of an order of 100 days requires a very high Doppler factor $\delta > 30$ and a small viewing angle for this distant quasar. We are going to monitor 0858–279 in order to collect information on jet kinematics.
5. Assuming a "standard" model for a compact synchrotron source we estimate the magnetic field strength of the dominating component to be of an order of $\sim 0.1\delta$ mG.

We thank Margo and Hugh Aller for observing 0858–279 and calibrators quasi-simultaneously with the VLBA experiment which helped to calibrate the polarization data.

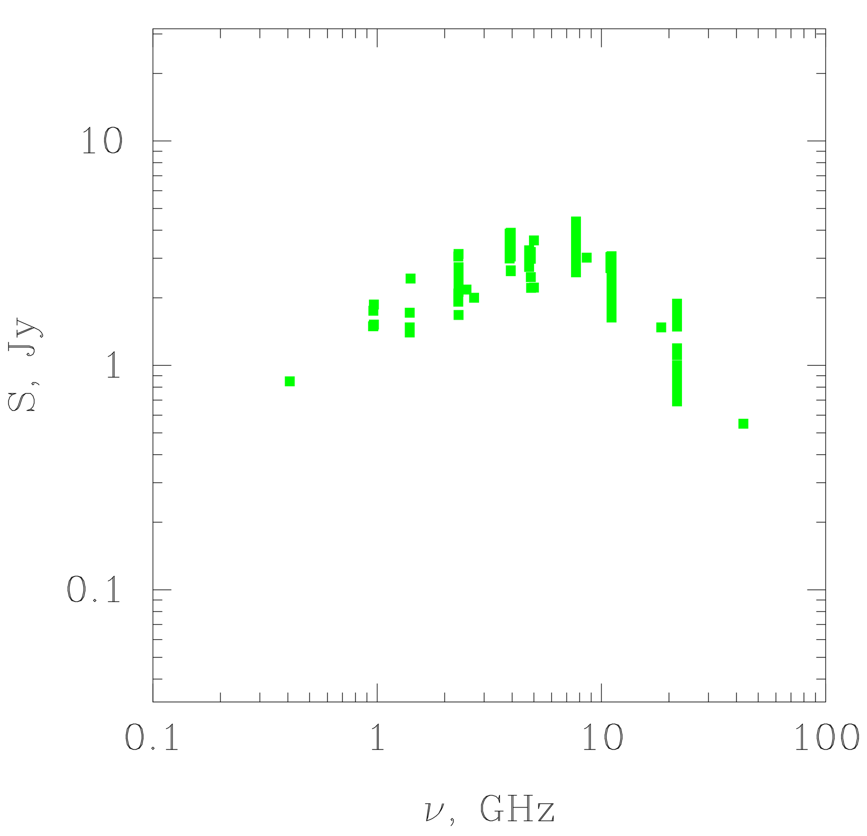

Figure 1. Multi-epoch radio spectrum: RATAN data at 31, 13, 7.7, 6, 3.9, 2.7, & 1.4 cm supplemented by data from the literature collected by the CATS database for the GPS quasar 0858–279. The flux density S is varying as much as $S_{\max}/S_{\min} > 2$, variability time scale is of the order of several months. The object shows GPS-like spectral shape at all observing epochs.

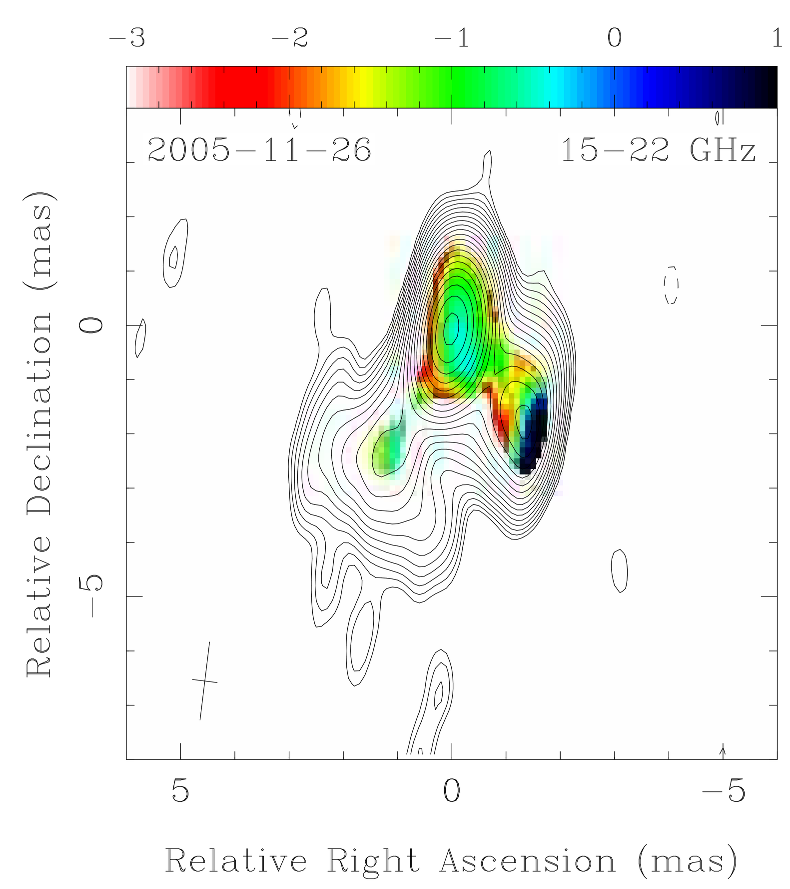

Figure 3. Spectral index image ($S \sim \nu^{\alpha}$) for the quasar 0858–279. Contour plot represents naturally weighted CLEAN image at 15 GHz. Spectral index is shown in color. The image clearly reveals the previously hidden core region with inverted spectrum. Phase referencing to a calibrator was performed in order to align 15 and 22 GHz images.

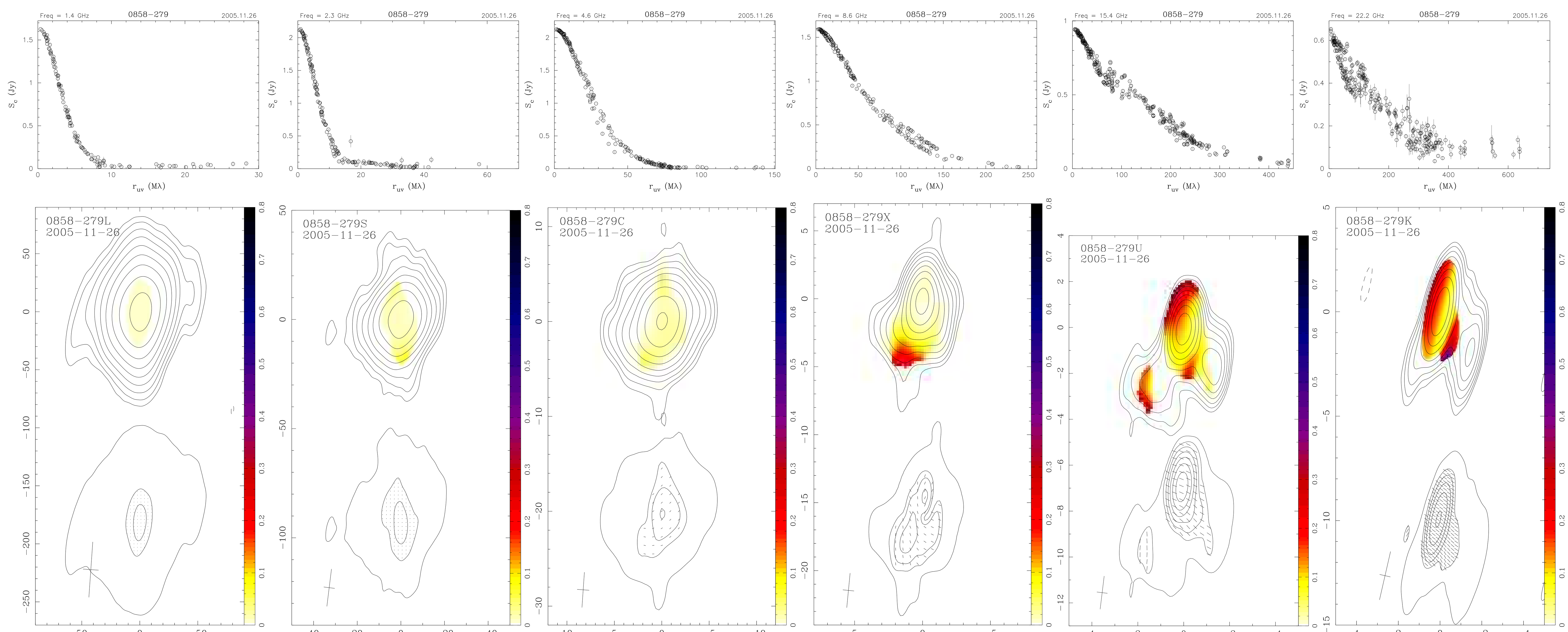

Figure 2. *Top:* Correlated flux density versus projected spacings dependence. *Bottom:* Naturally weighted CLEAN images: Stokes I and linear polarization. Fraction linear polarization is plotted in color.

References

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