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Connection between the extreme brightness of quasars and their radio flares

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The space very long baseline interferometry (VLBI) project *RadioAstron* has conducted a survey of 248 active galactic nuclei (AGN) [1]. Its highest achieved angular resolution is 10 μas, which allowed to study the sub-parsec-scale features unresolved for ground VLBI. The main result of the survey is a discovery of extremely high brightness temperatures of the order of $T_\mathrm{b} \sim 10^{13} - 10^{14}$ K in AGN, violating the inverse-Compton limit [2, 3]. Some possible explanations of the extreme brightness, such as synchrotron emission of relativistic protons or very high Doppler boosting, imply the relation between the extreme brightness and major radio flares in AGN cores. Other options, including continuous particle re-acceleration in shocks in the jets or magnetic reconnection in relativistic jet plasma, are not expected to be strongly related to flares in the cores. The latter processes form short-living features of extreme brightness in jets, but do not lead to a significant long-term increase of the sources' total radio flux density.

To understand the mechanism producing the extreme brightness of quasars, we investigated the relation between the brightness temperature of the sources measured by *RadioAstron* at 1.7, 4.8, and 22 GHz and their variability observed by ground single-dish radio telescopes RATAN-600 at 2, 5, 8, 11, and 22 GHz and OVRO at 15 GHz. We used two quantities to characterize the variability of the sources: an activity index R, defined as the ratio of the source's flux density to its median flux density among the whole period of observations, and the spectral index α ($S \sim \nu^{\alpha}$, where S is the flux density, ν is the frequency). When a flare occurs, first α increases, then R increases. We analyzed the correlation between T_b and R as well as between T_b and α as a function of the lag between *RadioAstron* and single-dish observations. We found that the correlation functions between T_b and both of these quantities have statistically significant positive peaks. The positions of the peaks indicate that the brightness temperature increases in the beginning of major flares in AGN at a given frequency or several months before them. Therefore, the extreme brightness of quasars is related to the core activity and is probably explained by a very high Doppler boosting or the emission of relativistic protons.

References

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