INTERSTELLAR SCINTILLATIONS AS A TOOL FOR INVESTIGATIONS OF HYPERFINE STRUCTURE IN EXTRAGALACTIC RADIO SOURCES

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Attempts to use interstellar scintillations (ISS) to study the fine angular structure of quasars and galactic nuclei have not yet met with any success. The main reason for this lies in the comparatively large angular size of the nuclear structure which has been investigated. If dependencies on wavelength for the scintillation index, flux and angular size of a source are taken into account (Ozernoy and Shishov, 1980), it appears that centimeter wave band rather than decimeter wave range used in previous work is most appropriate for observing ISS.

ISS and Angular Structure. A radio source can be regarded as a point one if its intrinsic angular size, ϕ_o, is less than $\phi_p \equiv a/L \simeq 10^{-5}$ sin b. Here $a \simeq 3 \times 10^{10}$ cm is the characteristic size of fine scale irregularities in the electron density of interstellar medium, and $L \simeq 150\ (\sin b)^{-1}$ pc is the thickness of the scattering layer for a source with galactic latitude b.

VLBI Observations of Scintillations. Observations of a radio source by VLBI allow the isolation of a compact component. Figure 1 shows the theoretical wavelength dependence of the scintillation index m both in the case when the angular size of a source, ϕ, does not depend on λ (dashed line) and in the case when ϕ is due to scattering by irregularities intrinsic to the source (heavy line), i.e. $\phi = \phi_s^{(o)} (\lambda \mathrm{cm}/3)^2$. Measurements of ϕ's for a number of quasars at meter wavelengths indicate that $\phi_s^{(o)} \lesssim 10^{-5}$ arc sec. If the scattering is not negligible, an optimum wavelength band for observing ISS is 3-30 cm. The contribution of the compact component, as compared with the extended one, is presumably the greatest at the short-centimeter side where m is expected to be 1-10%. The time-scale of the scintillations is expected to be $T = a/v \sim 3$ hours, v being the earth's orbital velocity.

VLA Observations of Scintillations. A system with angular resolution worse than about 0".01 cannot separate the scintillating from the non-scintillating halo (the latter is usually responsible for the main part of the radio flux from a quasar). The resulting scintillation index $m(\lambda)$ to be expected is shown in Fig. 2 both in an idealized case

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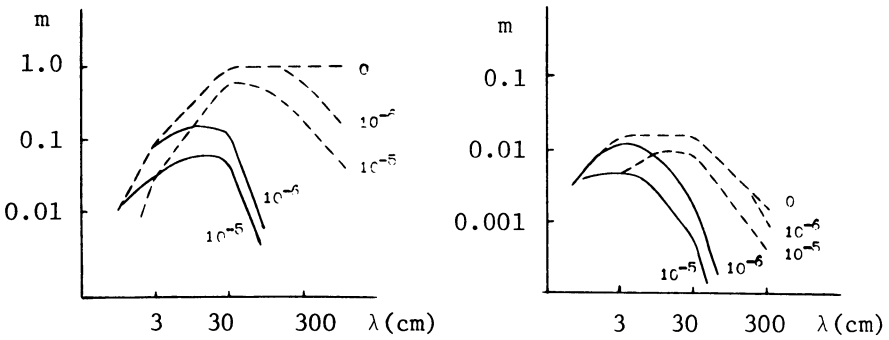

Figure 1. (left). Scintillation index as a function of wavelength when a source consists of the core alone.
Figure 2. (right). The same as in Fig. 1 when a source consists of the core and halo.

of the kernel whose angular size is independent of λ (dashed line) and in a more realistic case when the kernel size is determined by scattering (heavy line). In the latter case the ratio of the core flux, I_c, to the total flux, I, increases toward shorter wavelengths (Andrew et al. 1978) and can be fitted by the relation $I_c/I = (\lambda cm/3)^{-1}$. The optimum wave range to observe ISS is, as before, a band around λ = 3 cm; the characteristic scintillation time remains the same (T ∿ 3 hours). But the scintillation index is decreased to roughly 1%. Nevertheless, the VLA system offers a unique opportunity to measure the ISS by the differential method. Simultaneous measurements of the flux both from the kernel and from a non-scintillating component (e.g. a halo) allow us, in principle, to avoid the multiplicative inferences.

Implications. ISS can be used successfully for study of hyperfine ($3 \lesssim \phi \lesssim 100$ microarc sec) structure in radio sources and, therefore, would nicely complement the VLBI at cm wavelengths. Investigations of the substructure of compact radio components in QSS and galactic nuclei seem to be very effective in a combination ISS + VLBI. A combination ISS + VLA would allow to observe simultaneously several compact components and measure the scintillations of the hyperfine structure relative to the nonscintillating one of a larger size. Search for ISS from Sgr A West is of particular interest.

References

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