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Comments on "Experimental studies of electrostatic fluctuations in a turbulently heated plasma"

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Recently, Hamberger and Jancarik[1] reported very detailed measurements of spectra of potential fluctuations in a toroidal discharge (the "Twist" apparatus, at Culham Laboratory) using double electrostatic probes. The fluctuating potential difference between the two probe tips is recorded on a fast oscilloscope and, after corrections for nonuniform system sensitivity over the frequency range, spectral densities $[\langle V^2(\omega)\rangle \text{ vs } \omega]$ are obtained by means of standard analysis.

The authors distinguish three phases, or regimes, in their discharges (A, B, and C), according to the actual value of the electron drift velocity in the plasma. Here, we are mainly concerned with their type A regime and, particularly, with their observation of ion-acoustic turbulence (see Fig. 9 of Ref. 1). The maxima in $\langle V^2(\omega)\rangle$ seen in this figure are interpreted by the authors on the assumption that "the probe response $V(\omega)$ gives the true measure of the amplitude of the wave potential when it is in spatial resonance with the wave, i.e., $K = p\pi/d$, where p is an odd integer" (d is the distance between probe tips). They identify the maxima in the $\langle V^2(\omega)\rangle$ spectra with the spectral intensity, $I(\omega)$, (Fig. 12), and compare $I(\omega)$ with the predictions of Kadomtsev's theory[2] for ion-acoustic turbulence, as well as with a more recent theory by Tsytovich.[3]

The work of Hamberger and Jancarik has deserved and received wide recognition in the current literature.

It occurs to us, however, that, in spite of the very remarkable care and exhaustiveness of the Culham experiment, the procedure followed in order to obtain their Fig. 12, and similar data, is suspect for the following reasons:

(a) If the interpretation of the $\langle V^2(\omega)\rangle$ maxima in terms of a spatial resonance were straightforward, the maxima should be equally spaced along the frequency axis. This, however, is not the case (not even for maxima pertaining to the *same* shot, under the same experimental conditions).

(b) For a spatial resonance to be operative one should require that any given ion-acoustic perturbation be little attenuated over a distance of the order of the probe tips separation ($d \approx 10^{-1}$ cm). However, Fig. 15 of Ref. 1 indicates that even for the dominant fluctuations (thereby for those *least* attenuated) the product (wave angular frequency) $\times$ (correlation time) is ≈ 5 to 10 in the A regime. This means a correlation time, τ_c, approximately equal to the wave period T, ($\tau_c \approx T$). Alternatively, the attenuation length δ, is of the order of the wavelength λ, ($\delta \approx \lambda$). The authors state (and it can easily be checked) that the wavelengths of interest are typically in the range 10^{-3} to 10^{-1} cm. One concludes that, over very substantial portions of the measured spectra a spatial resonance condition is unlikely. The same holds true, although over a reduced frequency range, if the ordinate of Fig. 15 of Ref. 1 is taken to represent the product (wave frequency) $\times$ (correlation time).

In addition, wavelengths as short as $\sim 10^{-3}$ cm (i.e., $\omega \approx \omega_{pi}$), at any rate, appear hard to detect properly, because of spatial averaging, when the diameter of each probe tip is, as in the Culham experiment, $\sim 10^{-2}$ cm.

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[1] S. M. Hamberger and J. Jancarik, Phys. Fluids **15**, 825 (1972).
[2] B. B. Kadomtsev, *Plasma Turbulence* (Academic, New York, 1965).
[3] V. N. Tsytovich, *Non-linear Effects in Plasmas* (Plenum, New York, 1970).

