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Velocity Space Degrees of Freedom of Plasma Fluctuations[1]

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Small scale wave modes are becoming more important in plasma physics. Examples include turbulent cascades in the solar wind[1], the energetics of fusion plasma electrostatic turbulence and transport[2][3], and low temperature basic plasma physics experiments[4]. In order to improve our understanding of these modes, I present an advance in experimental plasma diagnostics and use it to show the first measurement of a plasma ion velocity-space cross-correlation matrix. From this matrix I determine the eigenmodes of fluctuations on the ion distribution function as a function of frequency. I also determine the relative strengths of these modes - these are the velocity space degrees of freedom of plasma fluctuations. This measurement can detect the aforementioned smaller scale modes in plasmas through a localized measurement. The locality of this measurement means that it may be applied to plasmas in which a single - point velocity sensitive diagnostic is available and multipoint measurements may be difficult. Examples include *in situ* measurements of space plasmas, fusion plasmas, trapped plasmas, and laser cooled plasmas. This fact, combined with the new perspective it can give on small scale plasma fluctuations, means it may be used to further research on the above cited subjects. Much work remains on fully understanding this measurement. This measurement opens a velocity space interpretation of small scale plasma wave modes, and understanding this perspective from theory requires the application or invention of new mathematical tools. I discuss open problems to follow up on, which include questions from experimental, theoretical, and instrumentation perspectives.
[1] Howes et al, Phys. Rev. Lett. 107, 035004, 2011. [2] Terry et al, Physics of Plasmas 13, 022307 (2006). [3] Hatch et al, Phys. Rev. Lett. 106, 115003, 2011. [4] Ng et al, Phys. Rev. Lett. 92, 065002, 2004.

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