Resonance Broadening Revisited

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Wave-particle interaction in a weakly turbulent plasma is often well described by the quasi-linear theory. This theory is based on the field integration along the unperturbed orbit assuming the wave amplitude is finite but small. Dupree [1966] and Weinstock [1969] have pushed this theory one step forward. They include the effect of orbit change as broadening of the wave-particle resonance; their theory is called 'resonance broadening (RB)'.

A considerable number of papers have been published on RB in 1970s, mainly of theoretical interest, however, few papers are written on this subject recently. This is perhaps partially because of the fact that results comes from lengthy calculation of RB are not much different from those of quesi-linear theory practically. RB predicts, for instance, the increase of damping rate due to the broadening of the resonance. However, several factors of difference may not be important in space plasma physics, where quantitative evaluation of phenomena often has a great amount of uncertainty. Therefore observationists might well say RB is a 'theorists' toy', which have little in actual use.

In the present study, we try to make one further step on this topic; we formulate the effect of past particle orbit change as a stochastic process. RB incorporates the effect of orbit change only in the resonance width, and the history of the particle position/velocity is not precisely treated. We make use of the technique of path integral to calculate the effect of particle history properly. So far, we have obtained formal expression of the path integral, and the next step will be to find a tractable form of this integral. Whether the present theory ends up with another 'theorists' toy' or becomes a useful tool depends on the result of this tractable form.

References
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Weinstock, J., Phys. Fluids. vol12, p 1045, 1969.