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A mechanistic interpretation of the wave-particle interaction of Landau[1]

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There are two halves to the wave-particle interaction: first there is the effect of the wave on the resonant particles and second the effect of the resonant particles back on the wave. This presentation will focus on the second half of the interaction, which is usually described through Poissons equation, or equivalently, through a dispersion relation obtained from Poissons equation. For example, for the case of a Langmuir wave with phase velocity on the tail of a Maxwellian velocity distribution, the resonant electrons make a small imaginary contribution to the wave dispersion relation, which yields a small imaginary contribution to the wave frequency, implying wave damping. An alternate, more mechanical interpretation, starts from the observation that the wave-induced displacement of the non-resonant electrons satisfies an oscillator equation that is driven by the bare electric field from the resonant electrons. This field drives the oscillator resonantly since the resonant electrons travel at the wave phase velocity. From this perspective, the wave damping simply results from the drive of the bare electric field from the resonant electrons back on the wave oscillator. The resonant wave-particle interaction also occurs in waves that are governed by **ExB** drift dynamics, such as diocotron waves that are excited on a nonneutral plasma column. The column undergoes an **ExB** drift rotation, and at a resonant radius, the rotational flow matches the azimuthal phase speed of the wave, yielding a wave-particle resonance. Again a mechanical interpretation of the wave damping is possible. The bare electric field from the resonant particles produces **ExB** drift motion that symmetrizes the plasma column, that is, damps the wave. This mechanistic interpretation also works for the case of Landau growth and for the case where nonlinear effects, such as trapping, play a role in the resonant particle dynamics.

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