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The streaming instability

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Streaming instabilities are thought to play a fundamental role in both the processes of acceleration and propagation of Cosmic Rays in the Galaxy.
Resonant scattering on self-generated magnetic turbulence has long been recognized as the most plausible mechanism for the confinemet of energetic particles. The streaming of these particles along magnetic field lines at super-alfvenic speeds generates magnetic turbulence at a wavelength corresponding to the particles' gyroradius: such turbulence could then provide efficient scattering of the same particles so as to ensure a small diffusion coefficient and hence large confinement times in the Galaxy.
Particle streaming is even more important in the acceleration region, if galactic Cosmic rays up to the knee are indeed accelerated in Supernova Remnant shocks. Reaching energies in excess of 1 PeV requires very effective particle scattering, leading to infer a turbulent magnetic field in the shock region much in excess of the average field in the ISM. The field amplification is thought to be provided by the streamining CRs themselves, but sufficient levels of turbulence, such as to guarantee acceleration up to the knee, are still difficult to obtain, even after the resonant generation of Alfven waves is taken into account.

In more recent times, the streaming instability has been reconsidered to show that in addition to the well known and long studied resonant modes, there are also non-resonant modes in the dispersion relation, that might show in some situations very large growth rates, much larger than for the resonant ones. These non-resonant waves lead to magnetic field strengths that could ensure, in principle, acceleration of particles up to the knee. Problem with these modes, in terms of their efficacy for particle scattering (and hence acceleration) is that they are born as short wavelength modes and some inverse cascading is necessary before they can provide effective particle scattering.

I will give a brief overview of our understanding of streaming instabilities and their role in Cosmic Ray physics, following the historical development of studies in this field, from the pioneering works by Skilling and Wentzel in the '70s to the most recent works, both theoretical and numerical, on the non-resonant modes.

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