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Cosmic-ray Parker Instability and Galactic Plane Symmetry

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We study two-dimensional MHD numerical simulations of the Parker instability with the cosmic-ray pressure under the circumstance of the galactic disk. Instead of the symmetric boundary conditions on the galactic plane as often used, we solve the entire region of the disk. Numerical simulations show that the symmetric mode on the disk also grows when the cosmic-ray pressure is relatively large, while the glide reflection symmetric mode dominates on the disk when the cosmic-ray pressure is small. We confirm that the results are consistent with those of the liner analyses: the growth rate of the symmetric mode approaches that of the glide reflection symmetric mode as the cosmic-ray pressure becomes relatively large.

In the nonlinear stage, some loop structures of the magnetic field lines expand rapidly and grow into large structure when the cosmic-ray pressure is relatively large. Other loops, which start to grow a little later, are suppressed by faster growing loops located nearby and do not reach the nonlinear expansions. Eventually, the loop structure at the nonlinear stage is larger than that is expected form the linear analysis when the cosmic-ray pressure is relatively large.

When the nonlinear fast growing loops collide with another loops, the high density thin gas layers are formed by the compression between the loops. The figure shows the logarithmic density at that stage. Some of the high density gas shows filament structures and some of them look like high density loops. Similarities of these structures with some observational features and the relation of star formation activities can be studied further.

Keywords: MHD, Interstellar gas, Cosmic rays