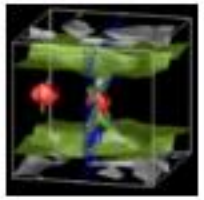

JEANS–PARKER INSTABILITY IN THE GALAXY

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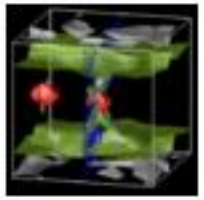
ASTRONOMY PROGRAM, SEES
SEOUL NATIONAL UNIVERSITY

JEANS

PARKER

JEANS-PARKER INSTABILITY

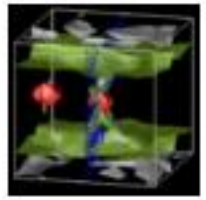


dynamical behaviors of the magnetized isothermal gas disk under the influences of

- **externally given gravity of stellar origin [J. S. Kim 1998]**
- **self gravity of the ISM itself [S. M. Lee 1999, 2001]**
- **both the external and self gravities**

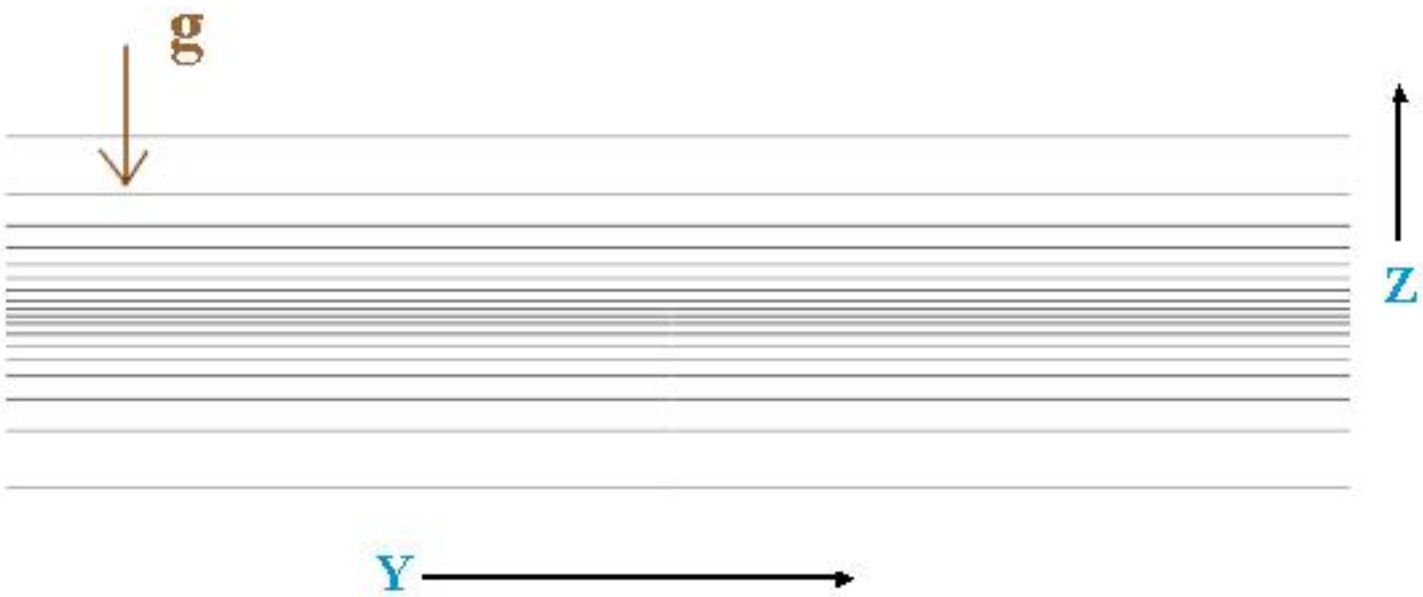
large-scale structures in the galactic environs
[GMCs, HI super-clouds]

CLASSICAL PARKER INSTABILITY

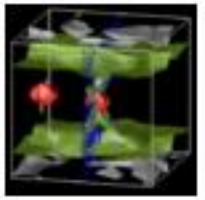


Initial Magnetic Fields

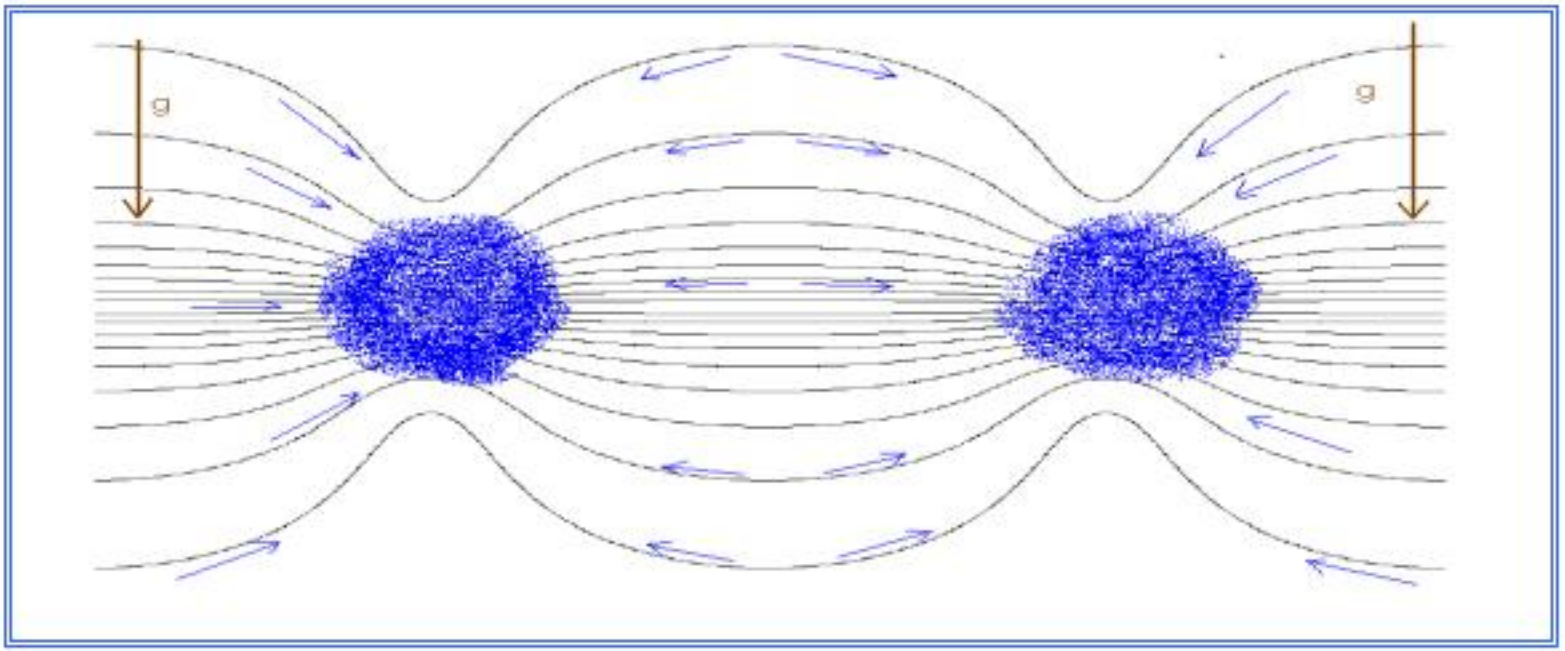
externally given uniform gravity of the stellar origin



CLASSICAL PARKER INSTABILITY



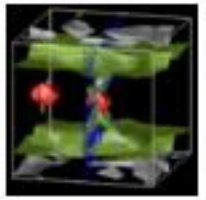
Undular Mode



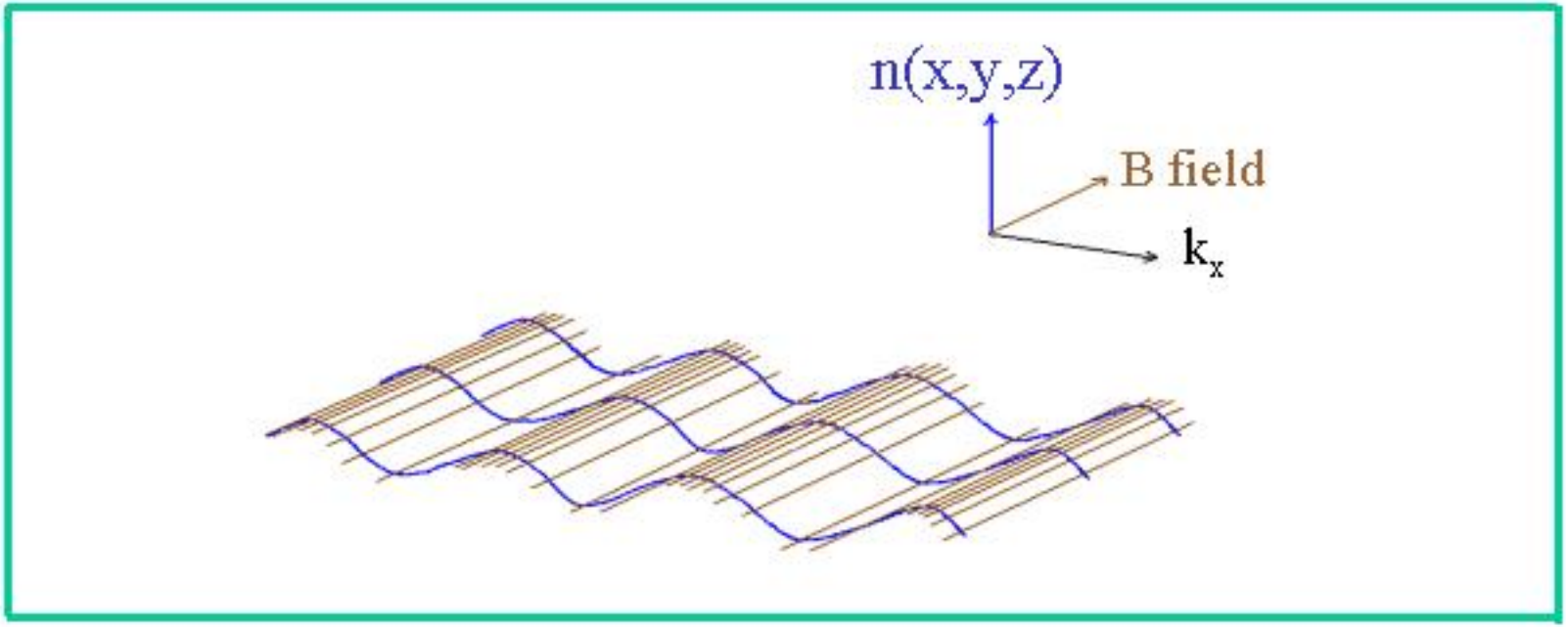
magnetic Rayleigh-Taylor instability

possible condensations in the magnetic valley

CLASSICAL PARKER INSTABILITY

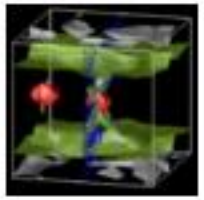


Interchange Mode



Convection would shred the ISM into chaotic sheets before the undular mode collects matter in the valleys.

CLASSICAL PARKER INSTABILITY

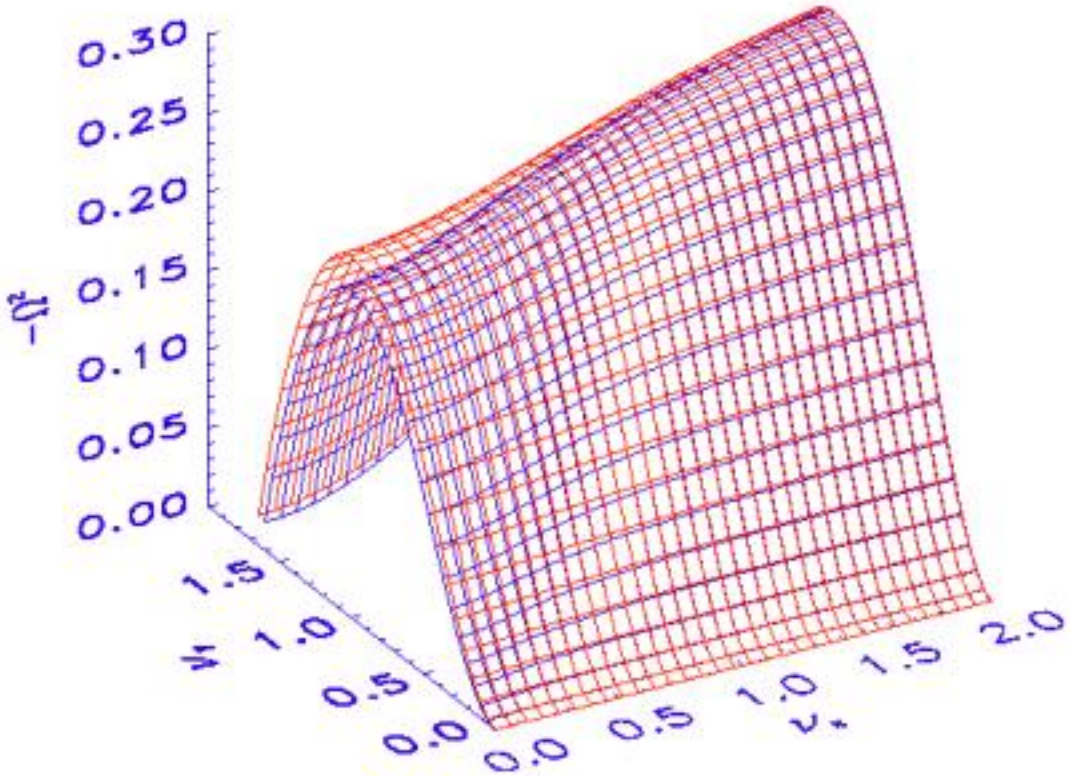


Dispersion Relations for the Mirror and Glide Symmetries

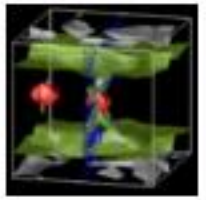
α =1.0

γ =1.0

ζ_a=5.0



CLASSICAL PARKER INSTABILITY



Column Density Maps from 3-D MHD Simulation

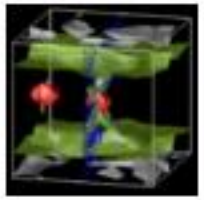
- **$N(x,y;\ t) = \int n(x,y,z;\ t)\ dz\ /\ \int n(x,y,z;\ o)\ dz$: face-on disk**
- **$N(y,z;\ t) = \int n(x,y,z;\ t)\ dx\ /\ \int n(x,y,z;\ o)\ dx$: radial column**

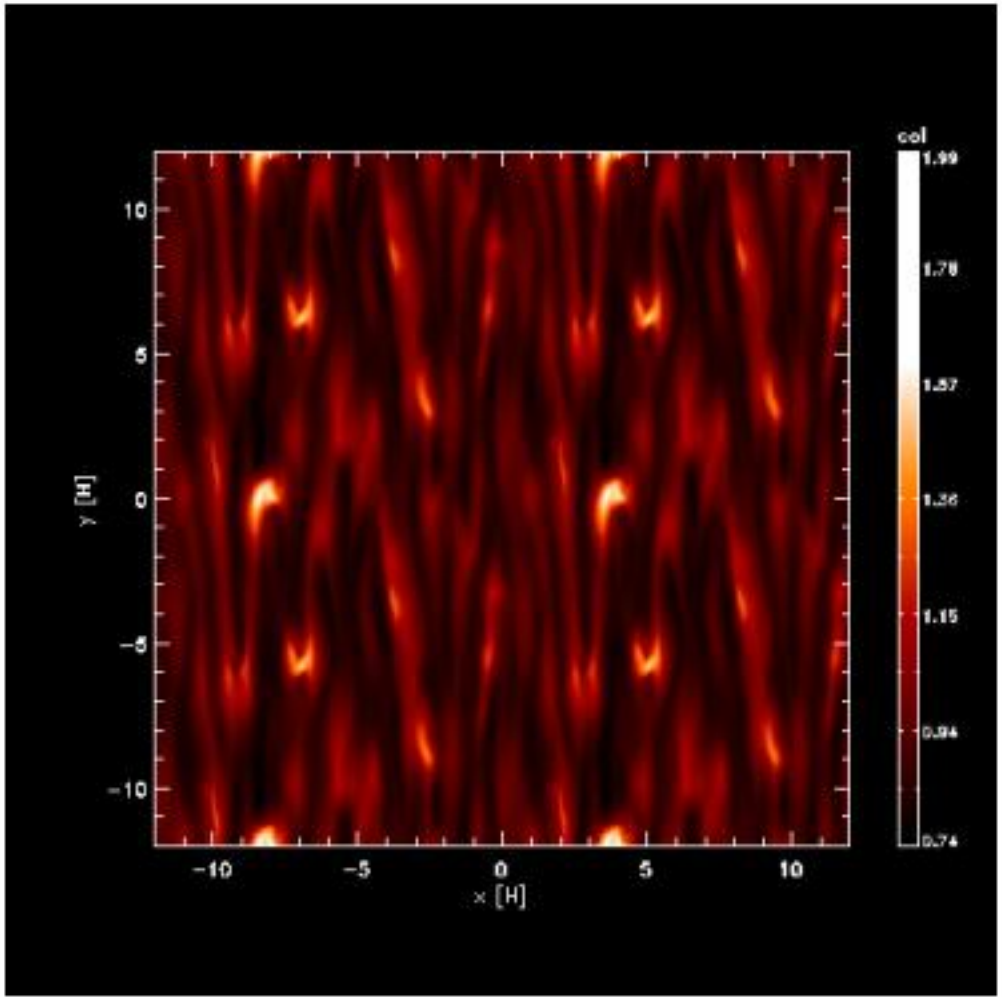
→ **degree of density enhancement**

JEANS

PARKER

CLASSICAL PARKER INSTABILITY

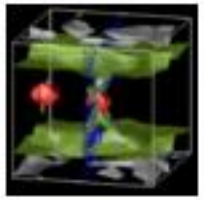


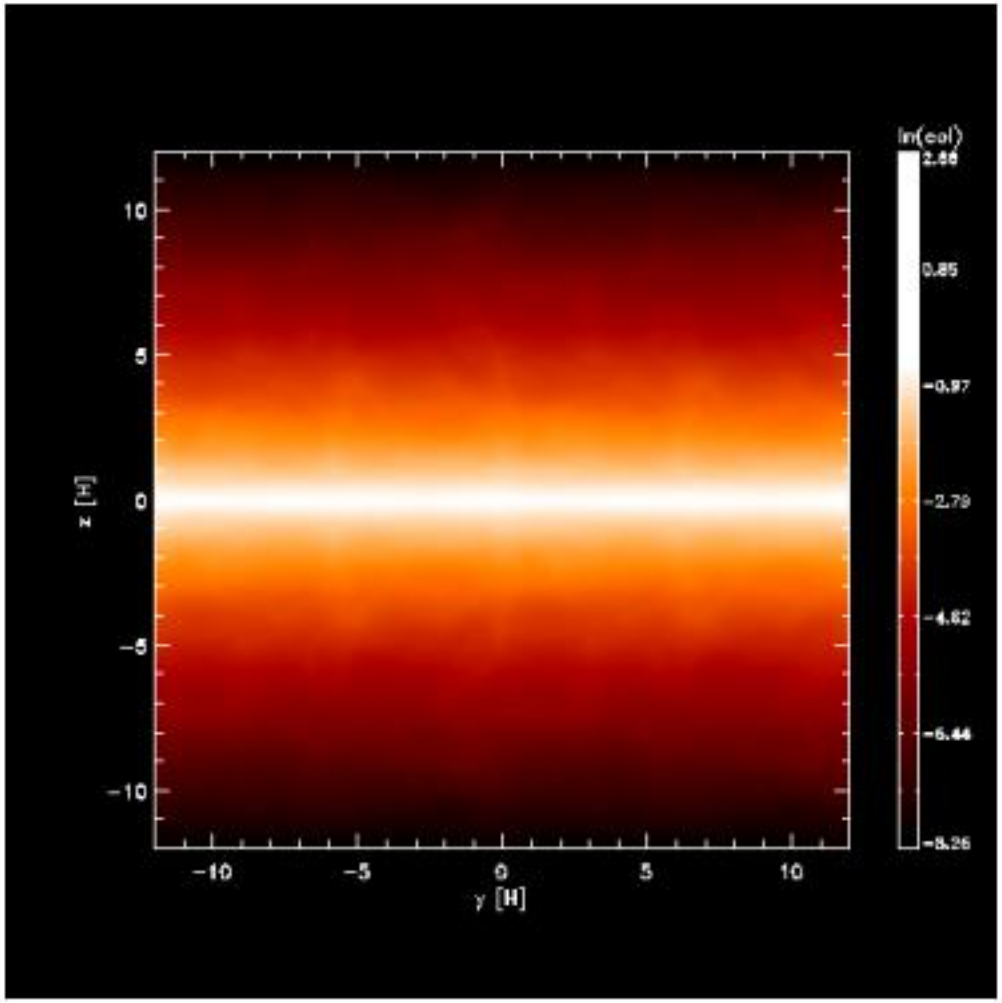


JEANS

PARKER

CLASSICAL PARKER INSTABILITY

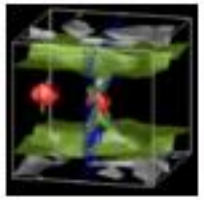




JEANS

PARKER

CLASSICAL PARKER INSTABILITY



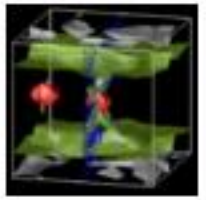
- **The scales involved with the undular mode can be compatible with the inter-spacing of the galactic GMCs.**

- **The interchange mode may not completely wash out the features of the undular mode, but the final outcomes are shredded thin sheets rather than dense clumps.**

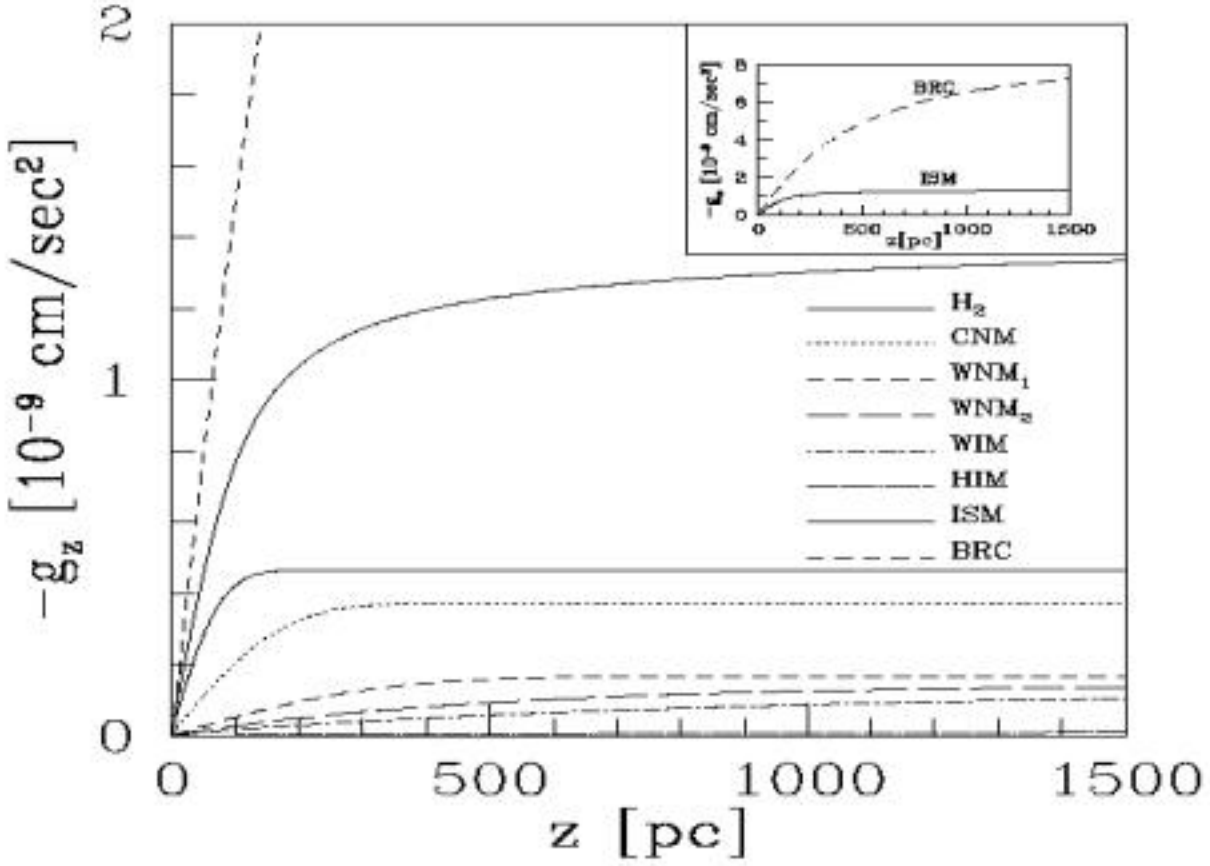
- **Furthermore, the resulting degree of density enhancement is insufficient to render interstellar clouds of the GMC type.**

The classical Parker instability alone can not be a viable mechanism for forming the GMC scale structures in the Galaxy.

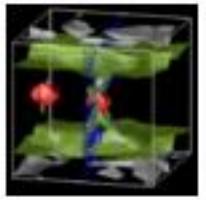
PARKER UNDER SELF GRAVITY



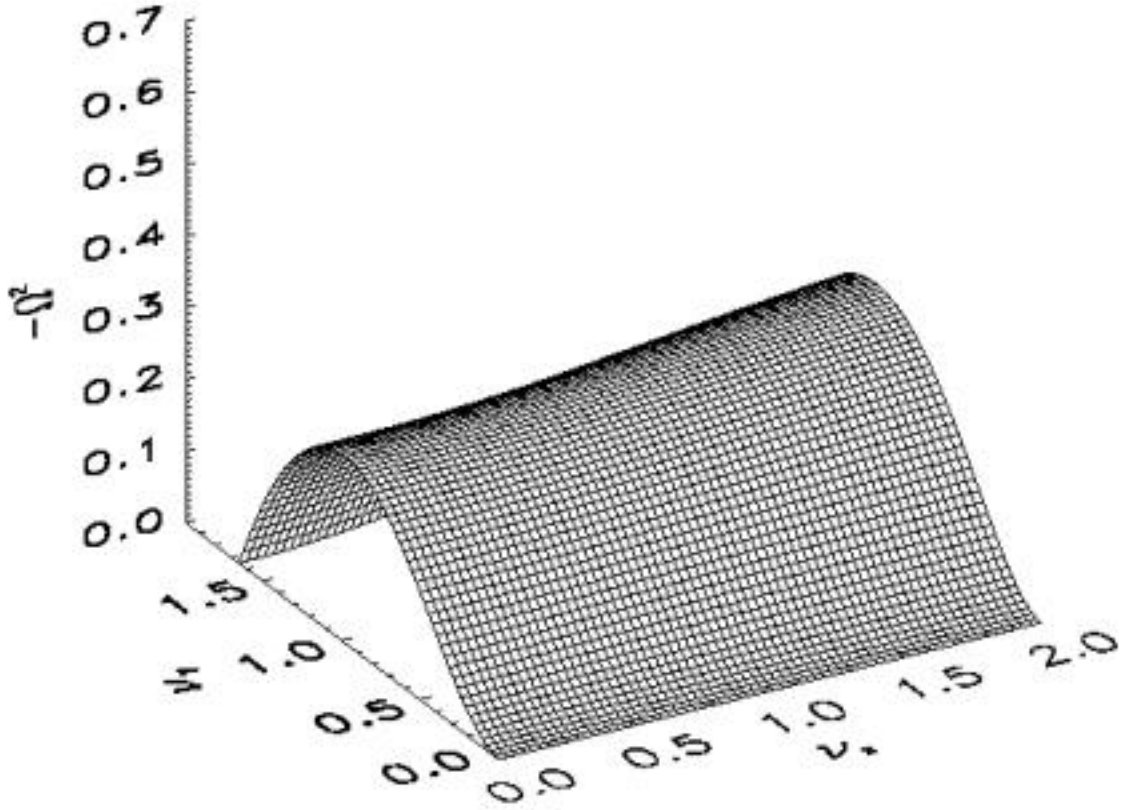
Self vs External Gravity



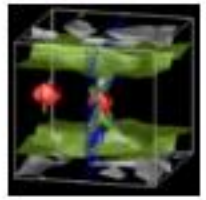
PARKER UNDER SELF GRAVITY



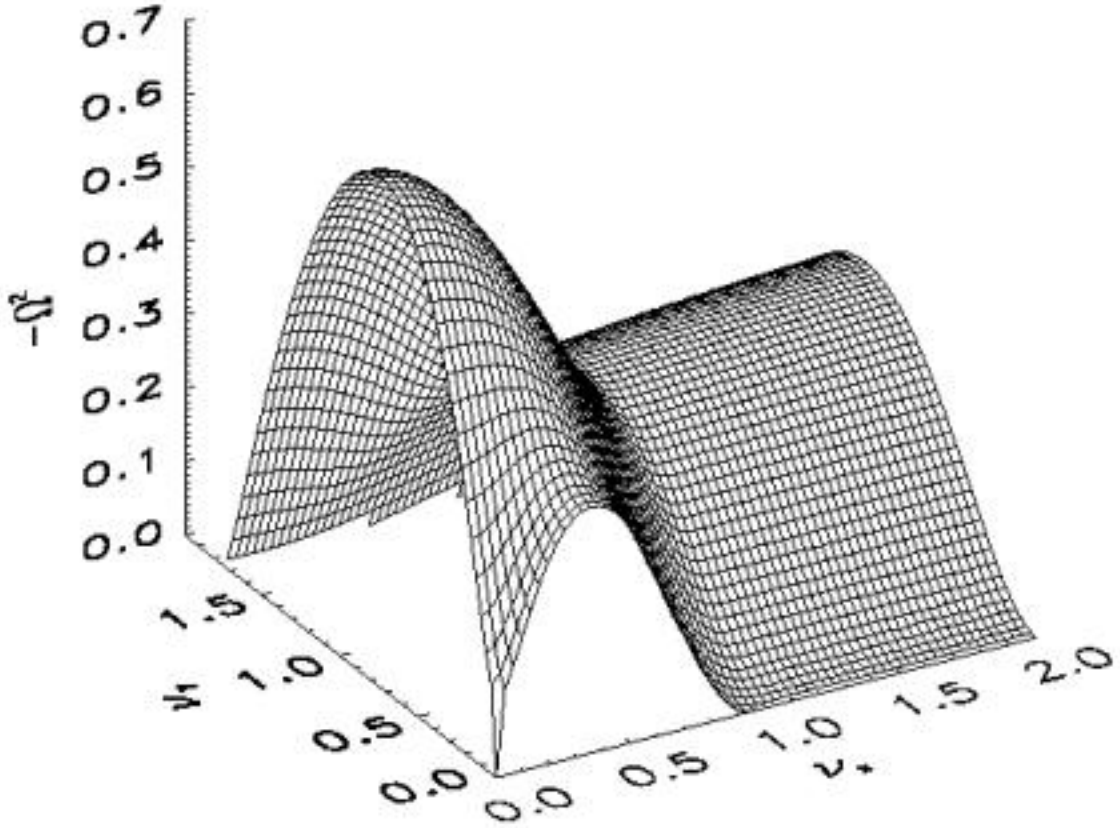
Dispersion Relation for Glide Symmetry



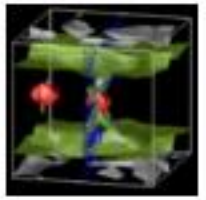
PARKER UNDER SELF GRAVITY



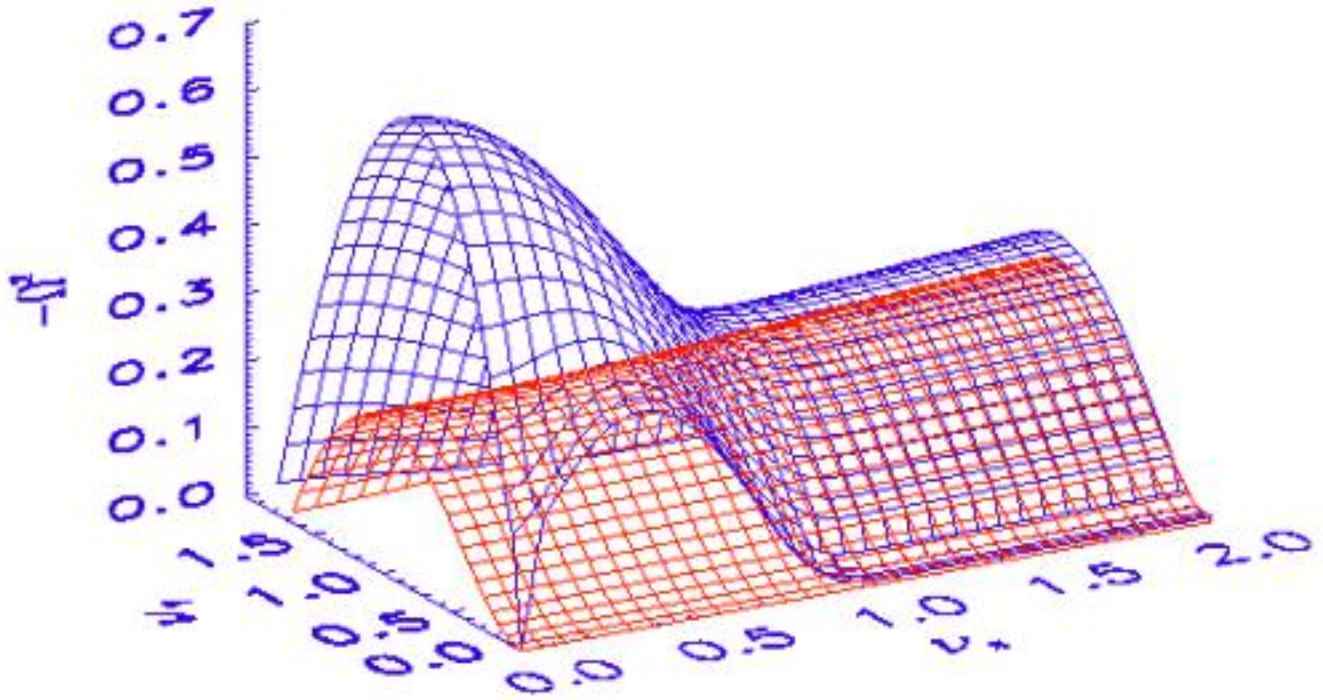
Dispersion Relation for Mirror Symmetry



PARKER UNDER SELF GRAVITY



Dispersion Relations for Mirror and Glide Symmetries



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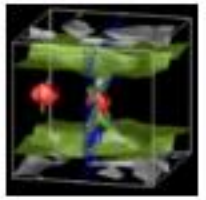
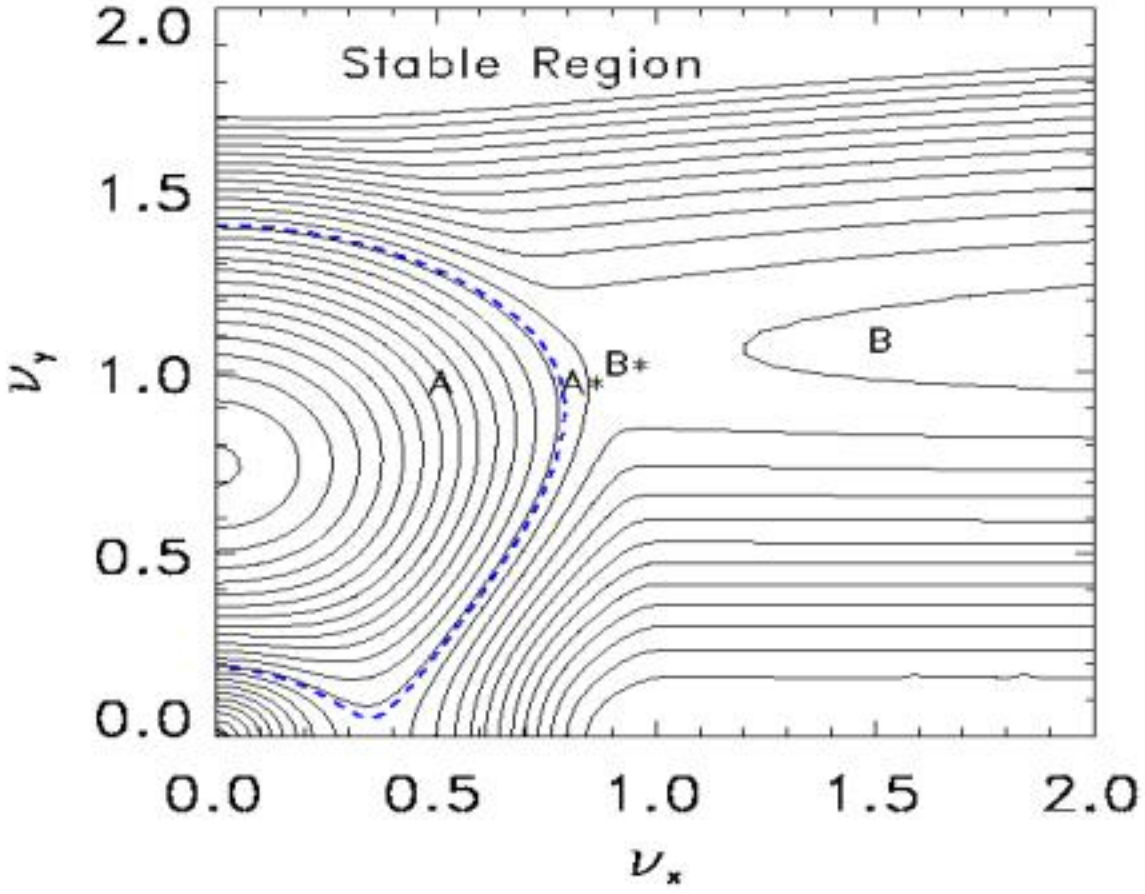


Equal Growth Rate Contours for Mirror Symmetry



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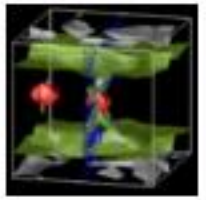
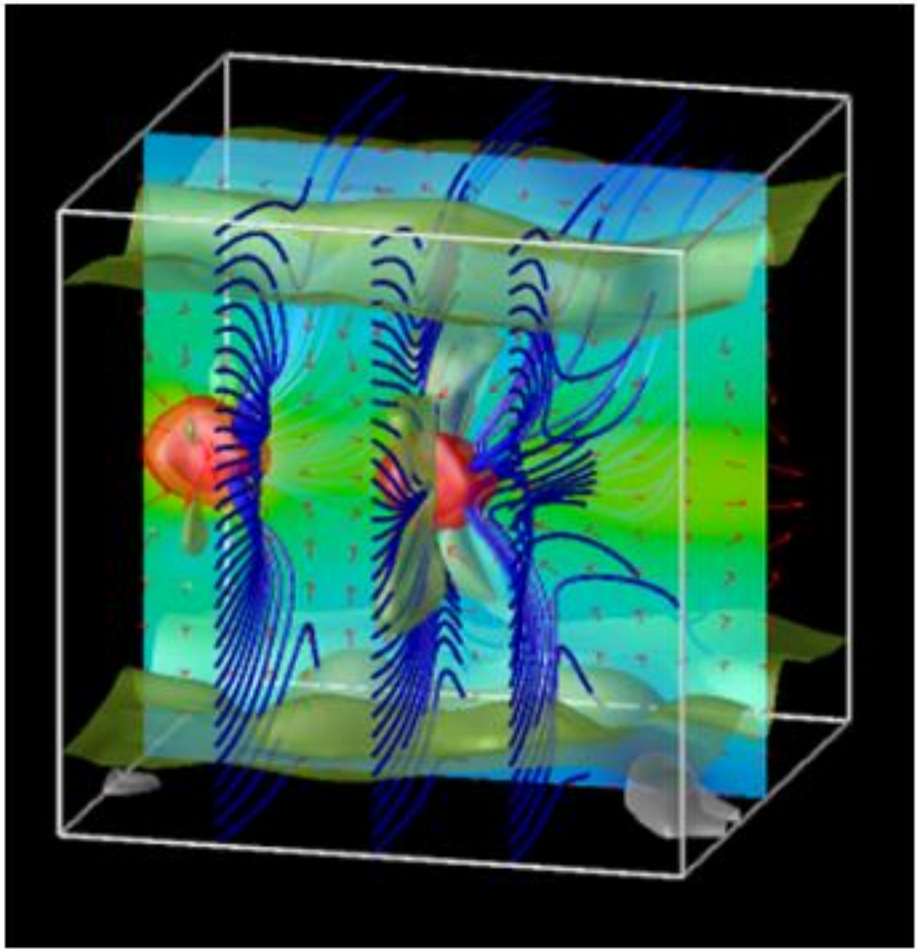
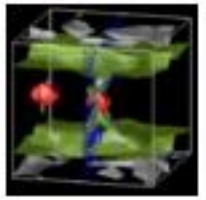


Formation of Dense Condensation from Model A

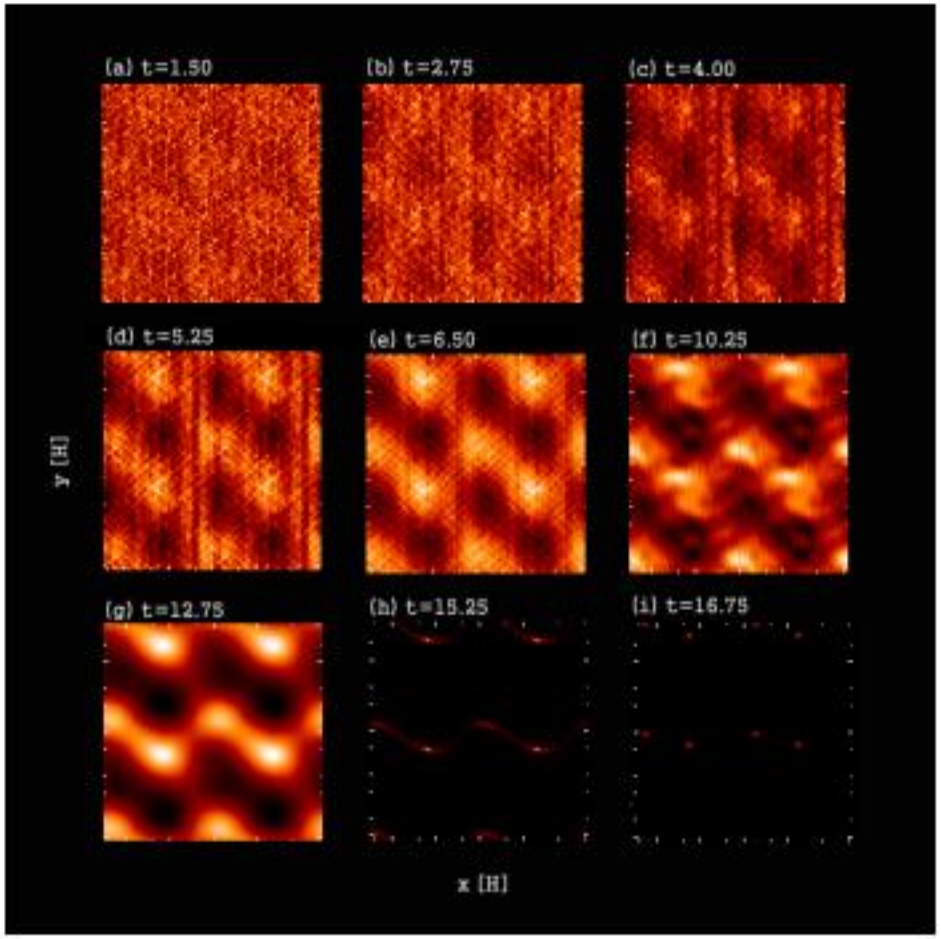


PARKER UNDER SELF GRAVITY

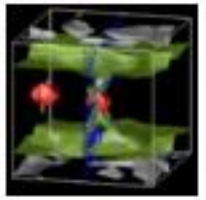


Column Density Maps N(x,y; t) for Model A

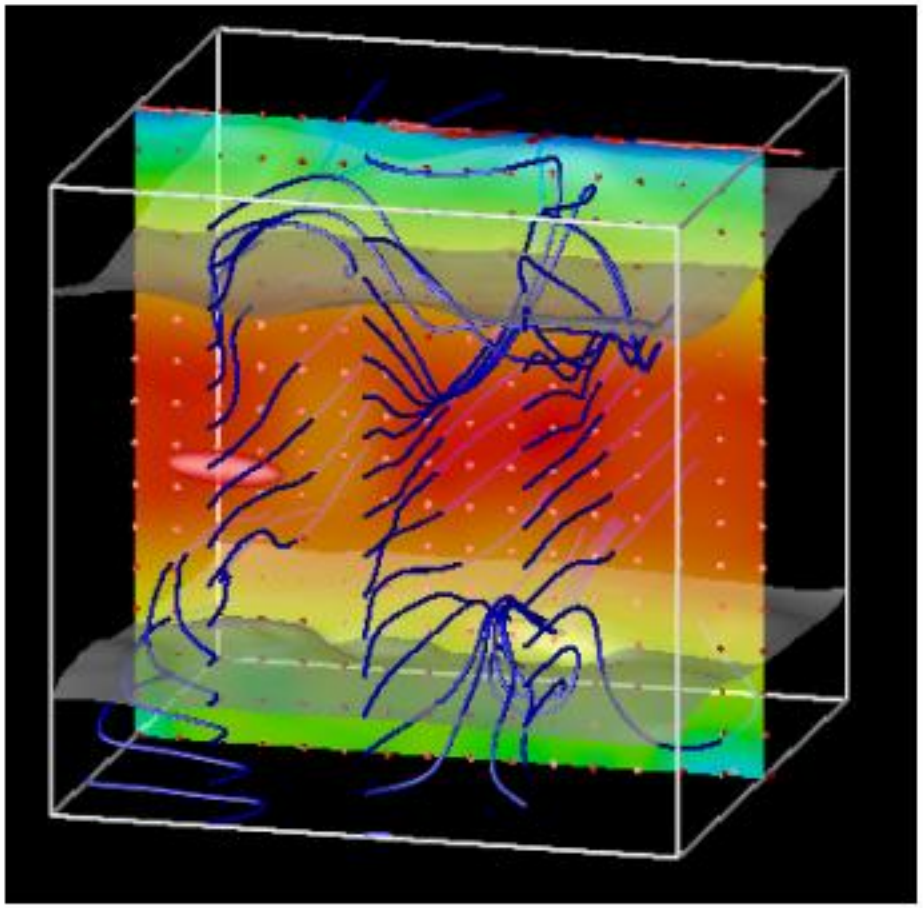
- interchange mode
- undular mode
- gravitational collapse



PARKER UNDER SELF GRAVITY



Formation of Dense Condensation from Model B



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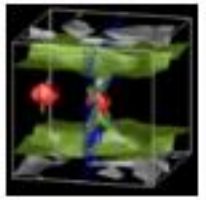
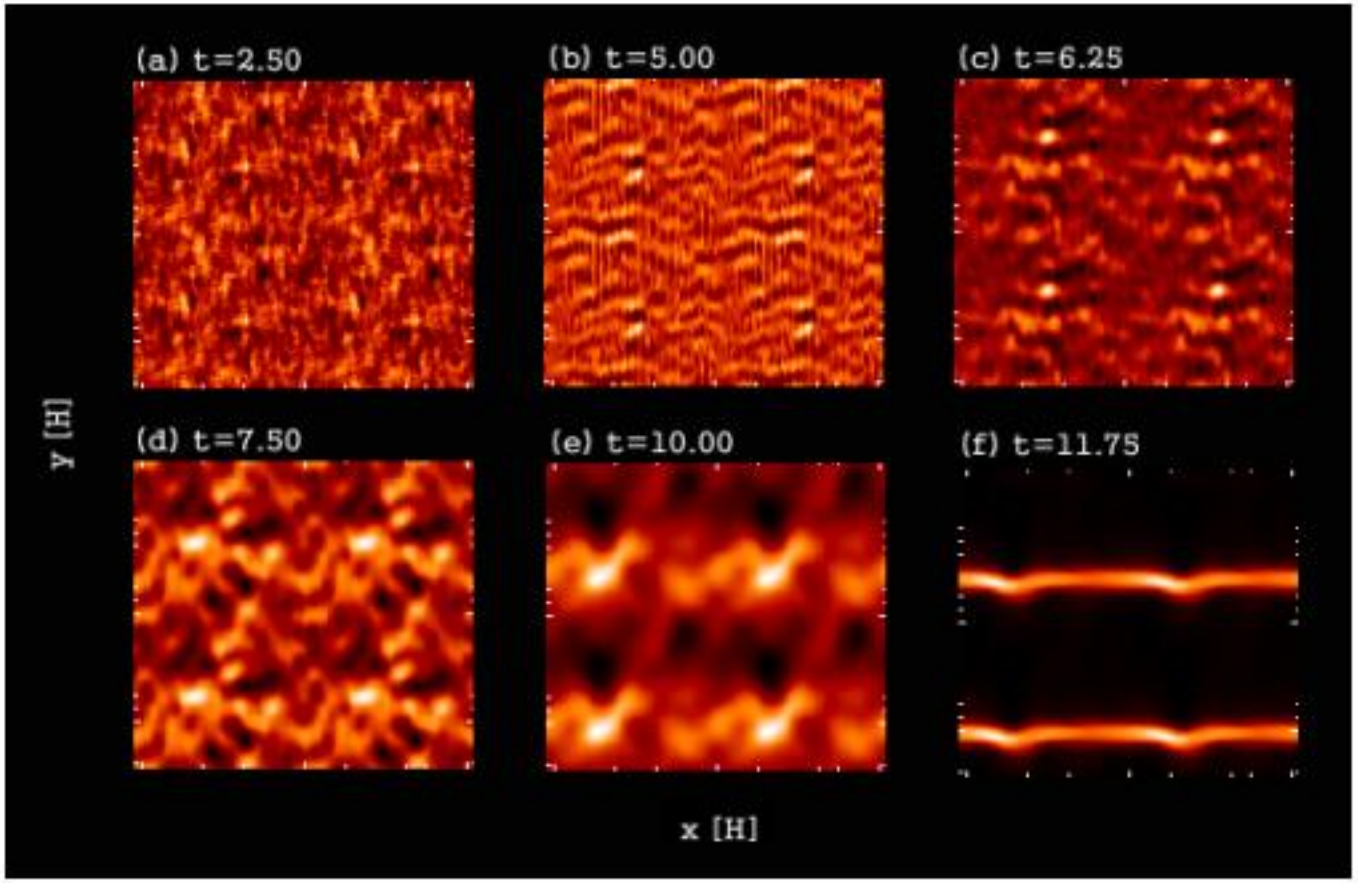


Column Density Maps N(x,y; t) for Model B



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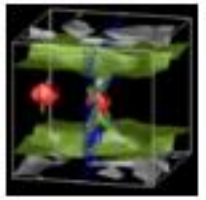
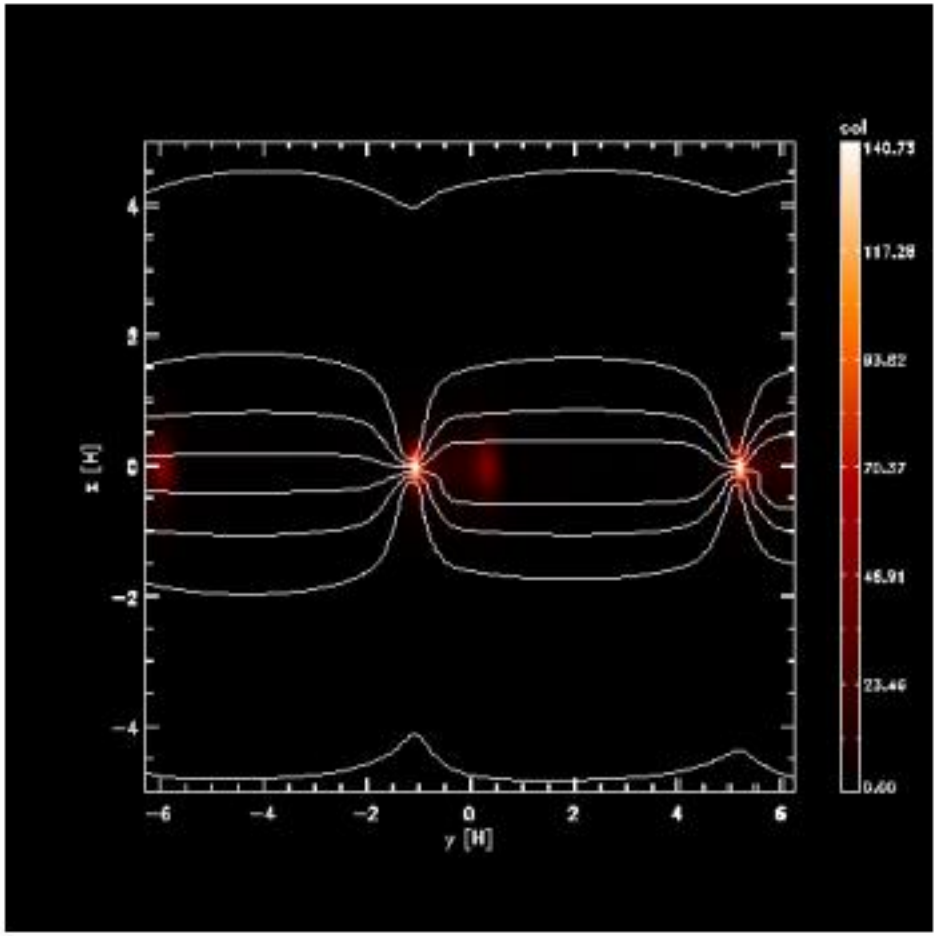


Column Density Map N(y,z; t) for Model A

magnetic field



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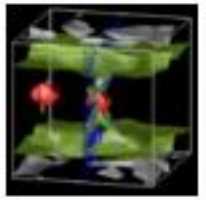
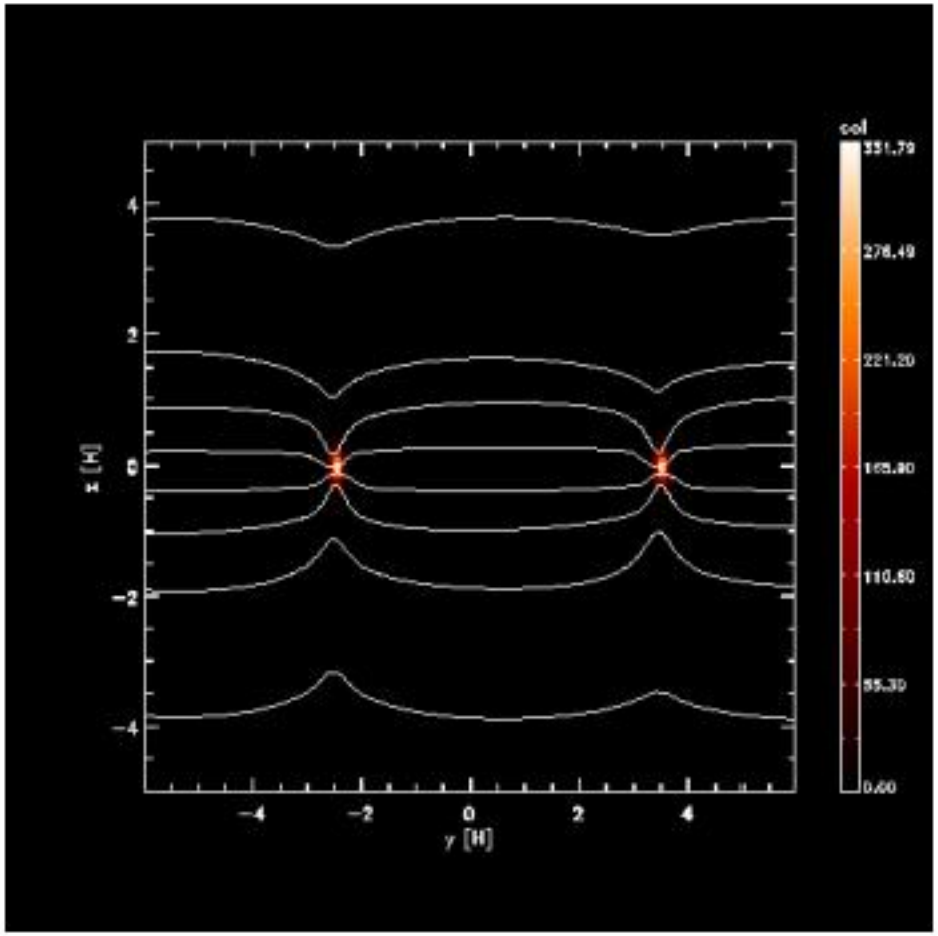


Column Density Map N(y,z; t) for Model B*

magnetic field



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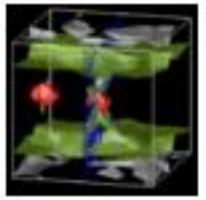
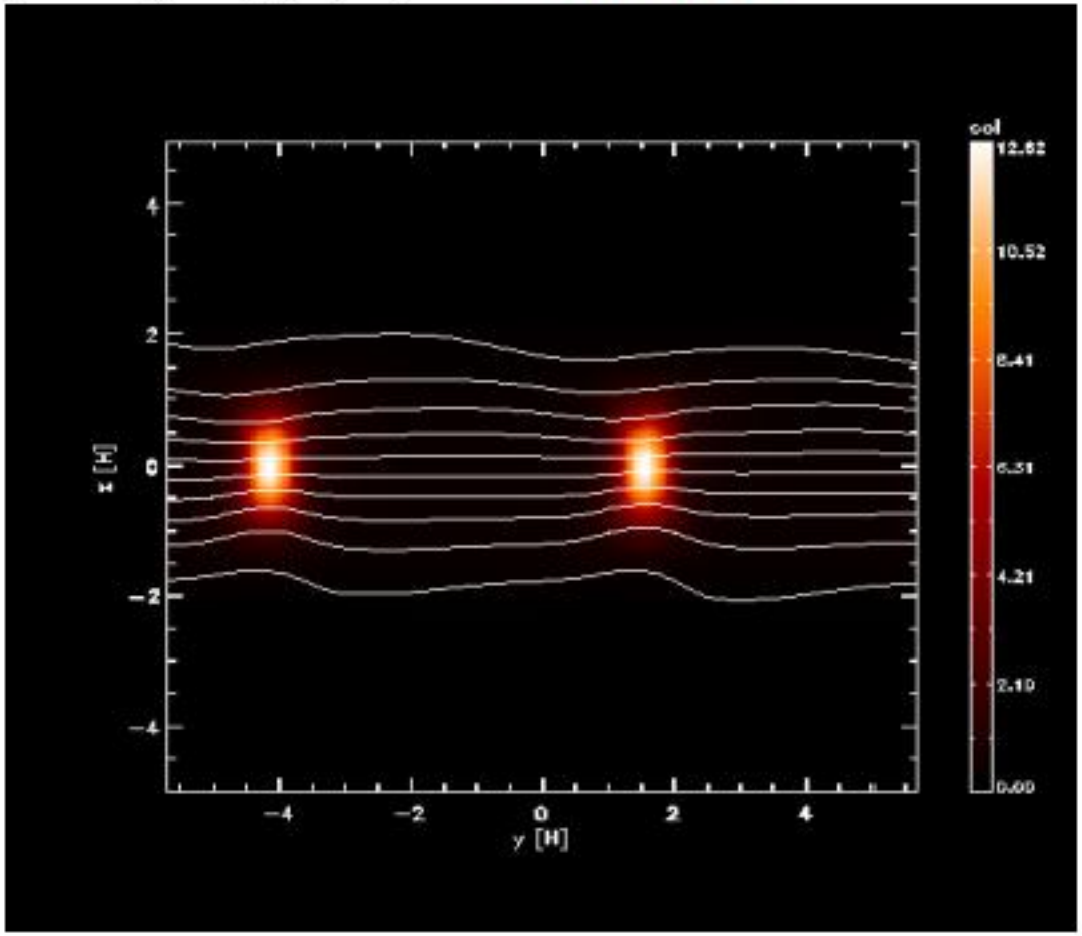
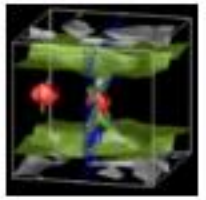


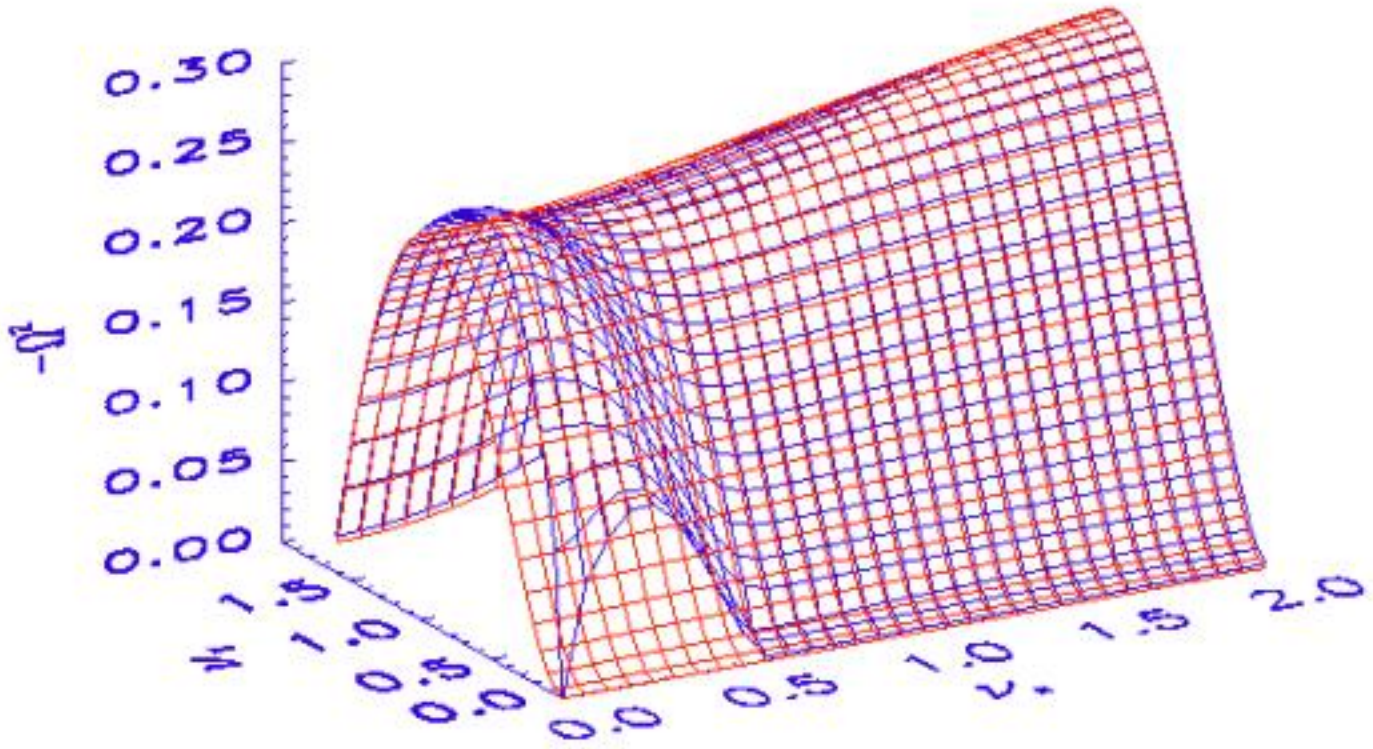
Column Density Map N(y,z; t) for Model B

magnetic field





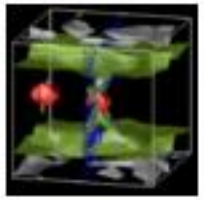
Dispersion Relation for Mirror and Glide Symmetries



JEANS

PARKER

JEANS-PARKER INSTABILITY



CONVECTION:

• **Under the Galactic ISM conditions the convection triggered by the interchange mode is completely suppressed down by the Jeans-Parker instability.**

DYNAMICAL EVOLUTION:

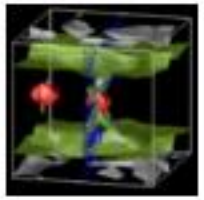
• **In the first stage of the evolution the external gravity drives the interchange mode, which is active in high altitude region, and then triggers the undular mode, which collects matter into the magnetic valley.**

• **When enough matter gets accumulated in the valley, the Jeans instability takes over the system from the Parker and forms dense condensations in the galactic mid-plane.**

JEANS

PARKER

JEANS-PARKER INSTABILITY

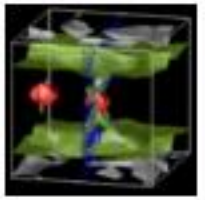


- **Final product of the Jeans-Parker evolution has an ellipsoidal shape whose long axis is perpendicular to the initial magnetic fields [thick disk].**

CONCLUSION:

The Jeans-Parker instability is a viable formation mechanism for such large-scale structures as the GMCs and HI super-clouds in galaxies.

JEANS-PARKER INSTABILITY



KEY REFRENCES:

a) linear stability analysis

Hong, S. S. and Kim, J. 1997, "Linear Stability Analysis of the Parker Instability under Non-Uniform Gravities" in Physical Processes in the Interstellar Medium, (Seoul : Min Eum), pp 263-331[in Korean]

Kim, J. and Hong, S. S. 1998, Ap. J., 507, 254

Lee, S. M. and Hong, S. S. 1999, Proc. of the 4th EAMA, p 293

b) numerical code

Kim, J., Ryu, D., Jones, T. W., and Hong, S. S. 1999, Ap. J., 514, 506

c) 3-D MHD simulations

Kim, J., Hong, S. S., and Ryu, D. 1997, Ap. J., 485, 228

Kim, J., Hong, S. S., Ryu, D., and Jones, T. W. 1998, Ap. J., 506, L139