Rotation induced Chiral Vortices and Inhomogeneous Condensation

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INTRODUCTION

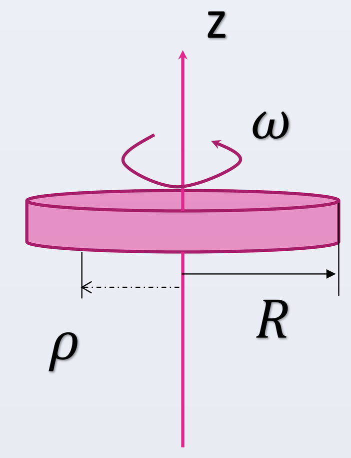
- Inhomogeneous Chiral Condensate

We develop a self-consistent theoretical framework to study the inhomogeneous chiral condensate and the possible chiral vortex state in rotating finite-size matter in four-fermion interacting theories.

Considering a rotating 2+1 D system with angular velocity $\vec{\omega}$.

In its rest frame,

$$H = H_0 - \vec{\omega} \cdot \vec{J}$$



Start from U(1) NJL model,

$$\mathcal{L} = i\bar{\psi}\bar{\gamma}^{\mu}\partial_{\mu}\psi + G[(\bar{\psi}\psi)^2 + (\bar{\psi}i\gamma_5\psi)^2]$$

It's renormalizable to avoid subtle regularization.

BOGOLIUBOV-DE GENNES EQUATIONS

- Bogoluibov-de Gennes Theory

Eigen-value eq.

$$\begin{pmatrix} K_L & \Delta(\vec{r}) \\ \Delta^*(\vec{r}) & K_R \end{pmatrix} \begin{pmatrix} u_n(\vec{r}) \\ v_n(\vec{r}) \end{pmatrix} = \epsilon_n \begin{pmatrix} u_n(\vec{r}) \\ v_n(\vec{r}) \end{pmatrix}$$

$$K = -i\gamma^0\vec{\gamma} \cdot \vec{\partial} - \vec{\omega} \cdot \vec{J} + \gamma^0(\sigma + i\gamma_5\pi)$$

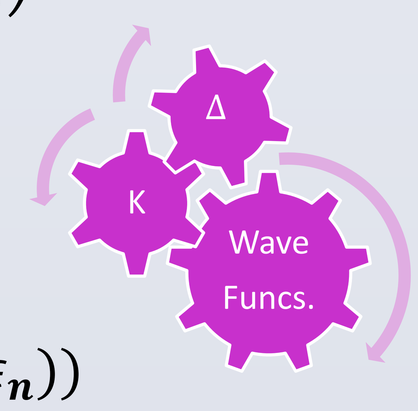
Chiral Condensate

$$\Delta(\vec{r}) = \sigma(\vec{r}) + i\,\pi(\vec{r}) = m(\vec{r})e^{i\phi(\vec{r})}$$

Gap eq.

$$m(\rho)e^{-i\kappa\theta} = G\sum_n v_n^{\dagger}(\vec{r})u_n(\vec{r})(1 - 2n_F(\epsilon_n))$$

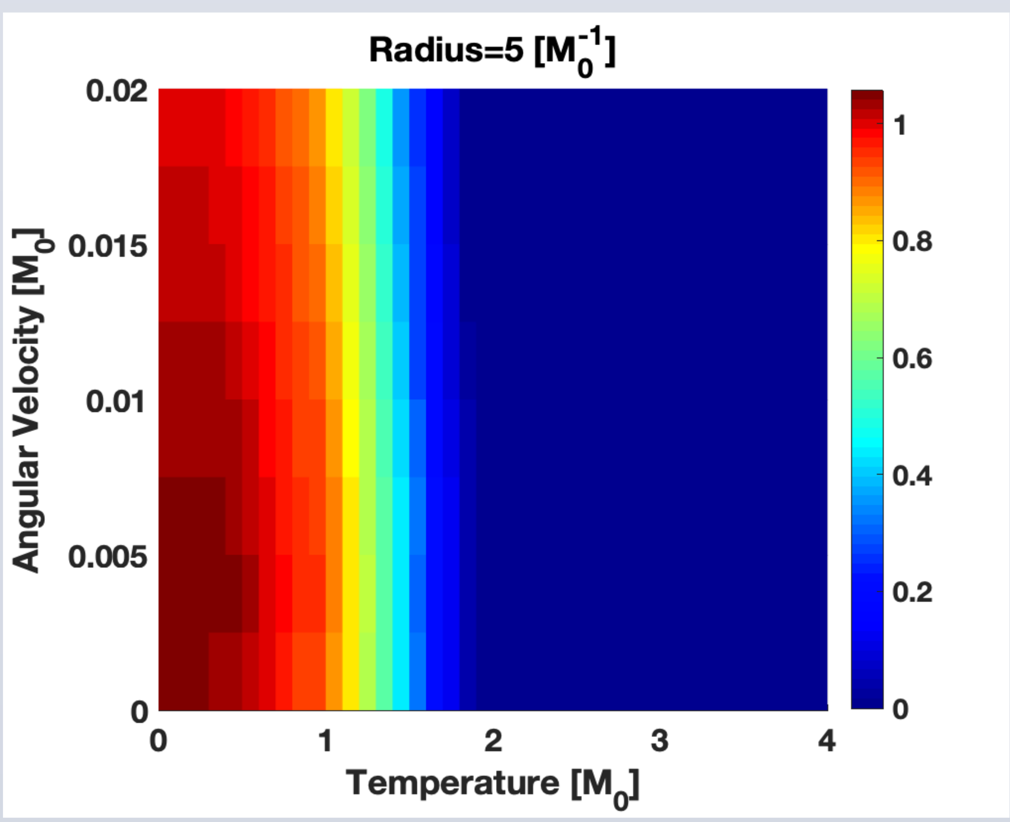
$$\kappa = 0, 1, 2, \cdots$$

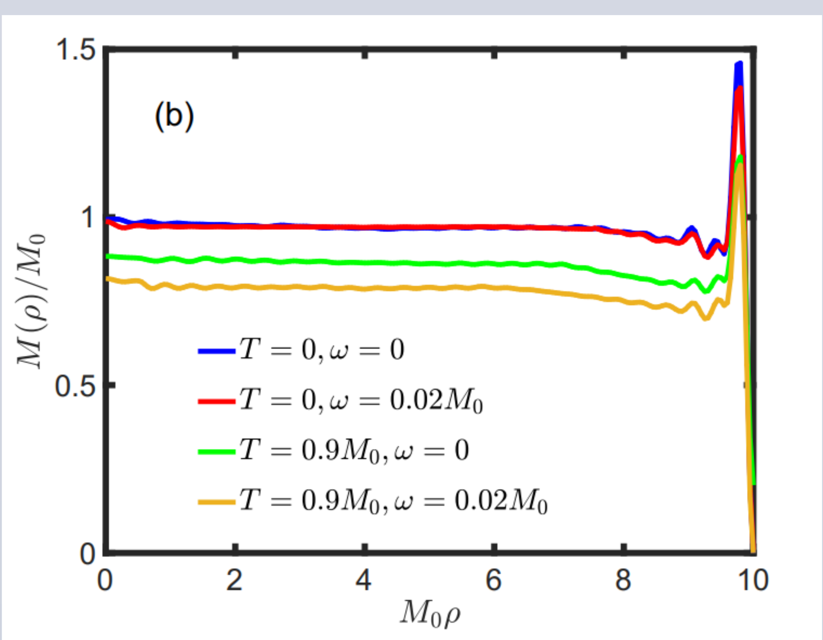


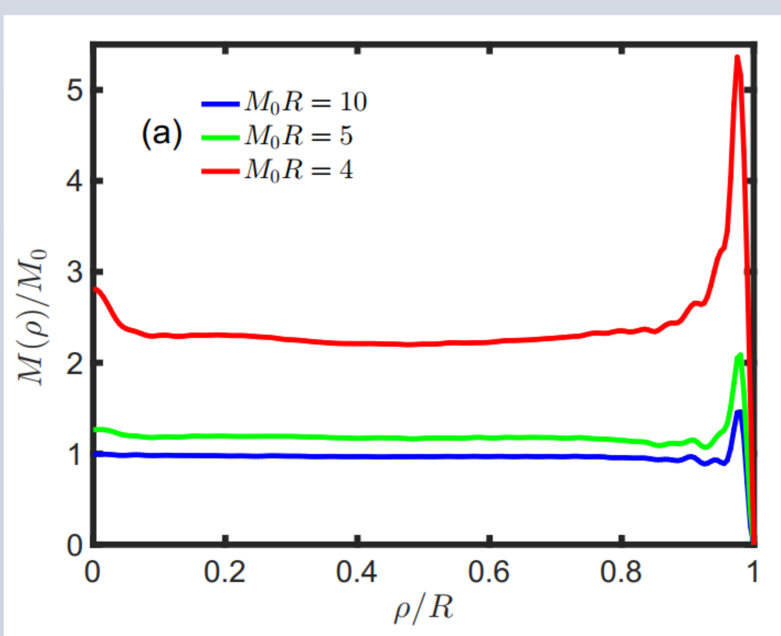
- Thermodynamic Potential

$$U_{eff} = \frac{1}{2G}\int d\vec{r}|\Delta(\vec{r})|^2 - \sum_n[\frac{\epsilon_n}{2} + \frac{1}{\beta}ln(1 + e^{-\beta\epsilon_n})]$$

- Condensates and Size-effects

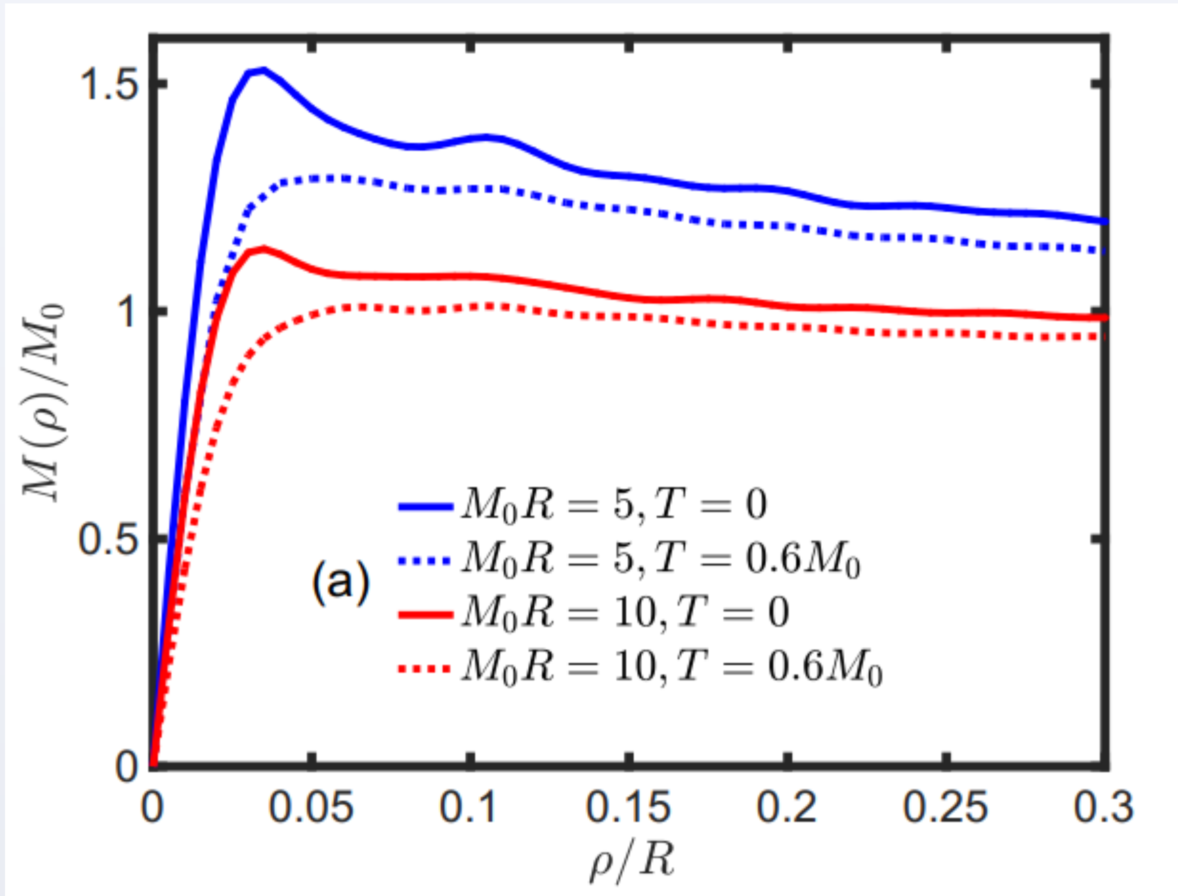




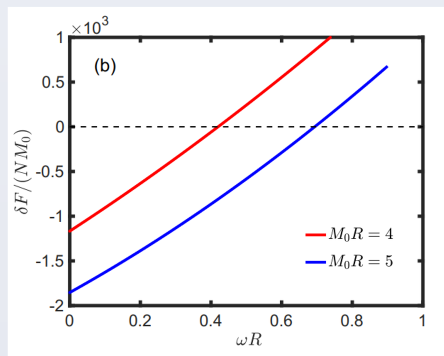


RESULTS-1-CHIRAL VORTICES

- Chiral Vortices

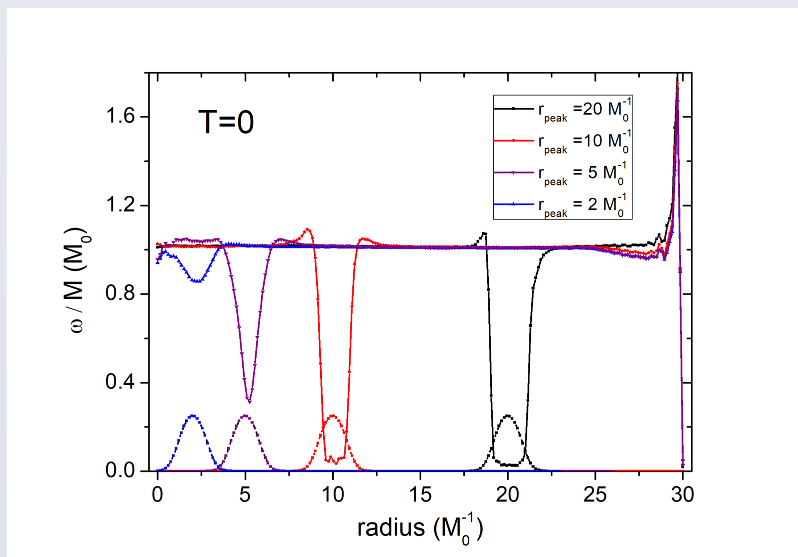


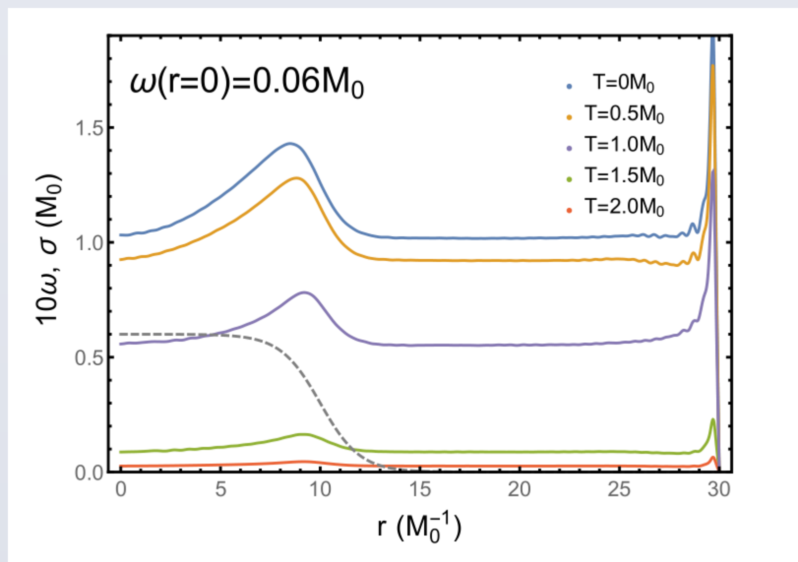
Chiral vortex dominates at large enough angular velocity. Free energy difference is $\delta F = F_{\kappa=0} - F_{\kappa=1}$ as a function of ωR



RESULTS-2-LOCALLY ROTATING

- Local Suppression Effect and Centrifugal Effect





Local effects due to rotation, vacuum can rotate!

CONCLUSIONS

- Chiral Vortex State

For sufficiently rapid rotation, the ground state of quark matter can be a chiral vortex state, a type of topological defect.

- Local Effects due to Inhomogeneous Rotation

Even at zero temperature condensates can significantly be modified by rotations.

ACKNOWLEDGEMENTS & REFERENCES

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