Anisotropic CFD Simulation Of Dipolar Gases In The Hydrodynamic Regime

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Abstract

In a recent theoretical effort, a hydrodynamic model of ultracold, but not yet quantum condensed, dipolar gases has been derived [1,2]. Within this model, the dipolar scattering results in an anisotropic viscosity tensor. Effects of the anisotropy have been predicted to be observable in the weltering motion, i.e., the collective oscillations of a dipolar Fermi gas [3], as well as in its acoustic behavior [1].
In this contribution, we approach dipolar fluids from a computational fluid dynamics (CFD) perspective. COMSOL Multiphysics © is an established method for fluid-flow simulations, available for many flavors of fluidic systems, but not yet with a predefined possibility to include an anisotropic viscous transport tensor that is needed for the envisaged hydrodynamic dipolar gases. Our approach to deal with the anisotropic behavior is, to overwrite the laminar flow standard expression for the viscous stress tensor in COMSOL using previously derived analytic expressions of the anisotropic viscosity tensor. This allows us to investigate a whole spectrum of fluid flow situations but now including the inherent anisotropy of dipolar scattering. We present first results of such CFD simulations with an emphasis on effects attributable to the special characteristics of the anisotropic viscosity tensor (see, for example, Figure 1).

Reference

[1] R. R. W. Wang and J. L. Bohn, Anisotropic acoustics in dipolar Fermi gases, Phys. Rev. A, 107, 033321 (2023).
[2] R. R. W. Wang and J. L. Bohn, Thermoviscous hydrodynamics in nondegenerate dipolar Bose gases, Phys. Rev. A, 106, 053307 (2022).
[3] R. R. W. Wang and J. L. Bohn, Viscous dynamics of a quenched trapped dipolar Fermi gas, Phys. Rev. A, 108, 013322 (2023).

Figures used in the abstract

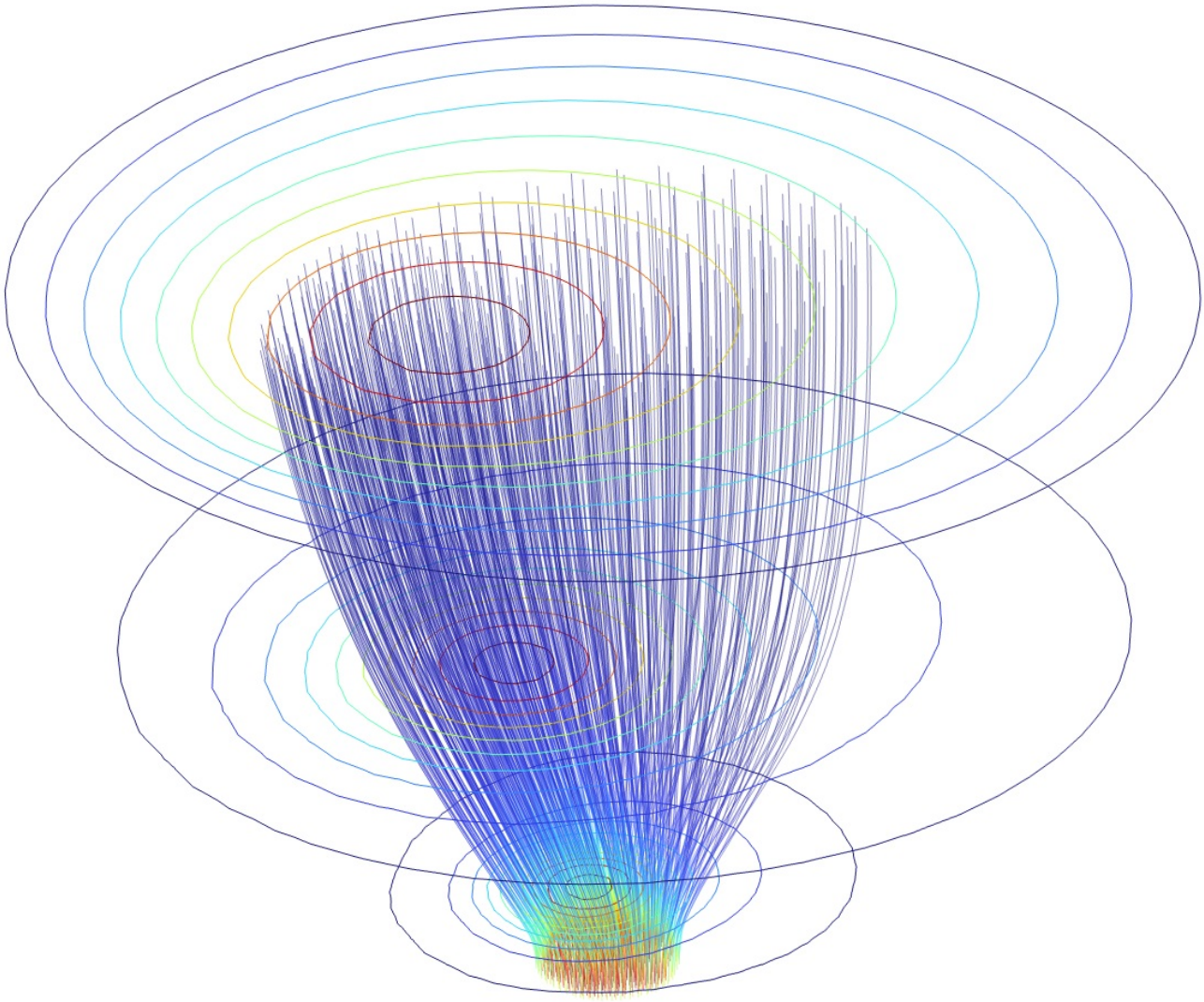

Figure 1 : Streamlines and contours of a flow through an orifice for a dipolar fluid with an anisotropic viscous stress tensor.