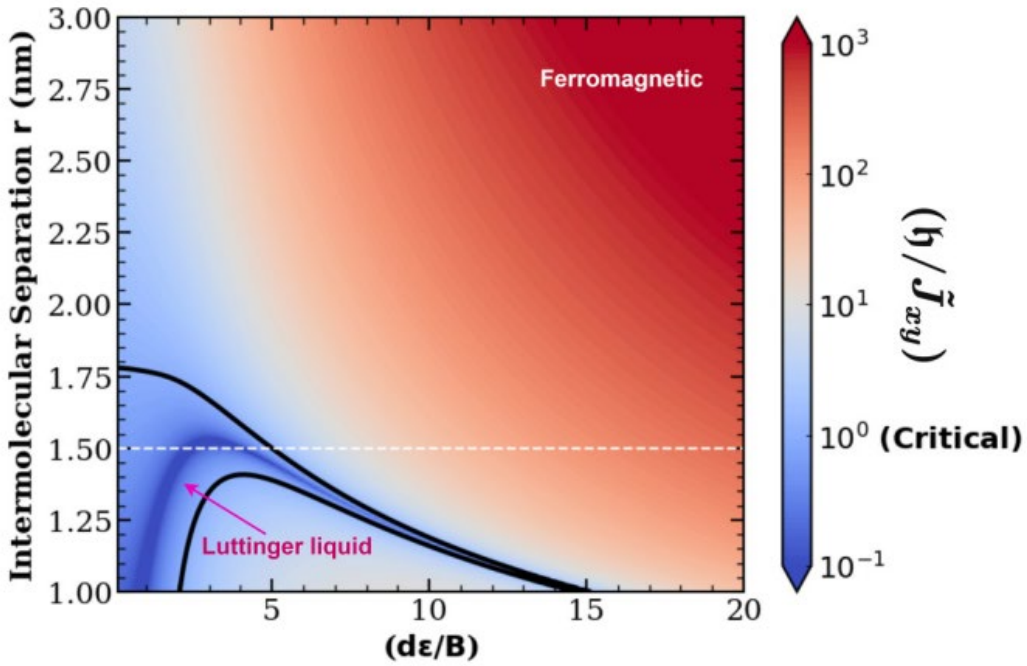
Emergence of a Luttinger liquid phase in an array of chiral molecules



Quantum phase diagram of the chiral molecular array vs. separation and field parameter.

Scientific Achievement

In arrays of trapped chiral molecules, we find that the Dzyaloshinskii-Moriya interaction emerges ab initio from molecular stereochemistry rather than being imposed phenomenologically, stabilizing a chiral Luttinger liquid phase.

Significance and Impact

Provides a direct microscopic link between molecular handedness and topological many-body phases, and yields a quantum simulator whose chiral coupling is continuously tunable by an external electric field, unlike solid-state platforms where spin-orbit coupling is fixed by the material.

Research Details

- Stark-dressed rotational states of asymmetric-top 1,2-propanediol are projected onto an effective spin-1/2 subspace, giving a generalized XXZ Heisenberg Hamiltonian.
- DMI arises from interference between the transition dipole moments of heterochiral (R-L) enantiomer pairs, which breaks inversion symmetry.
- Phase-diagram analysis identifies an optimal regime near r ≈ 1.5 nm separation and field strength dε/B ≈ 2.5.
- In that window the array avoids trivial field-polarized phases and hosts a robust gapless spin-spiral texture.

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- **NQISRC Intellectual Role:** *Lead*
- **NQISRC Funding Role:** *Sole*
- **Explanation of Funding Institution Contributions**
  - *Quantum Science Center: Supported theoretical development and computational simulations*