Miguel Ángel Sánchez-Martínez[1], Luke C. Rhodes[2], Blaise Goutéraux[3], Peter Wahl[2,4], Louk Rademaker[5], Felix Flicker[1]

[1] *H. H. Wills Physics Laboratory, Tyndall Avenue, Bristol, BS8 1TL, United Kingdom*
[2] *SUPA, School of Physics and Astronomy, University of St Andrews, Noth Haugh, St Andrews, KY16 9SS, United Kingdom*
[3] *CPTH, CNRS, École Polytechnique, Institut Plutechnique de Paris, Route de Saclay, 91128 Palaiseau, France*
[4] *Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany*
[5] *Department of Quantum Matter Physics, University of Geneva, CH-1211 Geneva, Switzerland*

Unraveling Pines' Demon in Sr_2RuO_4

In certain multiband metals, electrons in different bands can oscillate in anti-phase under the influence of an electric field. This results in the formation of a neutral mode termed the Pines' demon, a collective mode comprising two species of charged particles collaborating to sustain the collective motion's neutrality—an acoustic plasmon mode in three-dimensional metals.

The theoretical prediction of this phenomenon dates back to 1956 by D. Pines[1], yet its experimental validation materialized only recently[2] in Sr_2RuO_4. This work explores the Pines' demon in Sr_2RuO_4, incorporating beyond-RPA effects and accounting for surface contributions to the material's susceptibility.

While conventional approaches such as RPA and beyond-RPA corrections in both bulk and surface models predict the existence of an acoustic plasmon, they predict a linear dispersion intersecting the origin different from the experimentally observed dispersion reported[2]. Our analysis reveals that the inclusion of momentum-relaxation effects results in a modification of the linear acoustic plasmon dispersion compatible with the reported data, ruling out many-body interactions or surface effects as the origin of the experimental measurements of the Pines' demon in Sr_2RuO_4.

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