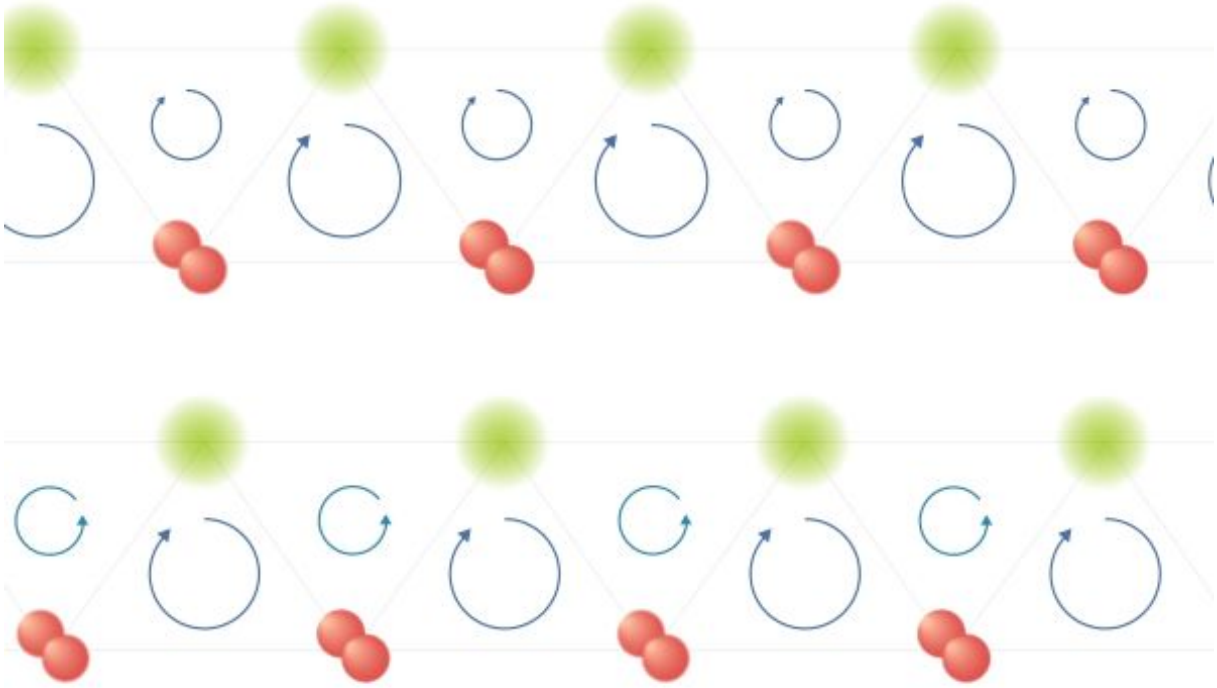

Supersolidity meets magnetism in an optical lattice

For the first time, a numerical simulation shows a phase of matter that combines lattice supersolidity and magnetism. The study, published in Physical Review Letters, proposes a concrete experimental setup to create and detect such states, something that, in the long run, could facilitate the development of exotic materials for quantum technologies.

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Supersolidity -an exotic phase of matter in which atoms flow without friction like a superfluid, while maintaining the periodic spatial order characteristic of a crystal- and magnetism are both at the forefront of physics research, despite having typically remained independent research topics. In a recent Physical Review Letters publication, however, an international team of researchers, including **Prof. at ICFO Maciej Lewenstein**, have theoretically studied and **simulated phases of matter that, for the first time, combine supersolidity and magnetism**. The researchers have also proposed a concrete experimental set-up based on magnetic atoms (in particular, dysprosium) for the creation and detection of such states.

To do so, first, atoms must be placed within an optical lattice, distributed in space like eggs in an egg carton. Dysprosium atoms are chosen precisely because they possess significant magnetic dipole moments, so that an atom placed in a specific spot of the i¿½cartoni¿½ can feel the magnetic repulsion not only from the atoms in the neighboring sites, but also rom atoms located further away. This ends up distributing atoms non-uniformly in sp ce, following a specific pattern as in a solid, but with the atoms flowing without lo ing coherence, thus creating a superso id. What the researchers have shown is that these atomic movements can generate finite cur ent fluxes, which effectively act as carriers of magnetic moments and, as such, can give rise o a non-zero magnetic field. Depending on the ordering of the fluxes, the result s a ferrimagnetic (if the fluxes spin in opposite directions but with unequal strengths or ferromagnetic phase (if they all rotate in the same direction), much like how anti-aligne or aligned electron spins produce magnetism in a mag et. i¿½The coexistence between lattice supersolidity and magnetic ordering of fluxes had never been studied before,i¿½ says Michele Miotto, researcher at the Technische Universita Berlin and first author of the article. i¿½And yet, we have now shown how to achieve a rea magnetic mate**the role of ?magnets' is played not by the magnetic particles themselves, but by current loops in a supersolid**.i¿ ? So far, their study has considered a one-dimensional system (that is, atoms arranged along a line), but the researchers hypothesize that extending this work to two dimensio s could reveal some insights about possible connections between supersolidity and topolo y, the field that studies how entanglement patterns in quantum materials with speci ic geometries produce different quantum phas

Reference:

Miotto M., et. al., Flux magnetism in a strongly interacting dipolar lattice supersolid under tunable gauge fields, Phys Rev Lett, **137**, 043401 (2026).
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