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SU(N) orbital magnetism and synthetic dimensions with two-electron fermions

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I will report on recent experiments performed at LENS with ultracold 173Yb Fermi gases. These two-electron atoms offer a range of new opportunities for quantum simulation with ultracold gases, since they grant the access to two stable degrees of freedom–nuclear spin and electronic state–that can be manipulated independently and coherently. By controlling the electronic state via an ultranarrow clock transition, we have obtained the first demonstration of fast, coherent spin-exchange oscillations between fermionic atoms trapped in two different long-lived electronic orbitals [1]. This result paves the way to the observation of exotic quantum magnetism and of paradigmatic condensed-matter effects in a fermionic system exhibiting SU(N)-invariant interactions. Finally, I will present the results of a very recent experiment, where we have used Raman transitions between different 173Yb nuclear spin states to synthesize an effective lattice dynamics in a finite-sized "extra dimension." By using this innovative approach, we have realized synthetic magnetic fields for effectively-charged fermions and we have demonstrated the emergence of chiral edge states propagating along the edges of the system, thus providing a direct evidence of a prominent feature of quantum Hall physics in condensed-matter systems [2].

[1] G. Cappellini et al., Direct observation of coherent inter-orbital spin-exchange dynamics, Phys. Rev. Lett. 113, 120402 (2014).

[2] M. Mancini et al., Observation of chiral edge states with neutral fermions in a synthetic Hall ribbon, preprint arXiv:1502.02495 (2015).