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Spinor Bose-Einstein condensates: from topological defects to synthetic Hall cylinders[1]

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Spinor Bose-Einstein condensates of dilute atomic gases have allowed physicists to access important quantum phenomena unattainable in other systems. Yang monopole was proposed more than seventy years ago as a fundamental ingredient in non-abelian gauge theories. It was recently delivered for the first time in experiments by tailoring four cyclically-coupled hyperfine spin states of ultracold atoms. In the first part of this talk, I will show how Yang monopoles could be simulated by ultracold atoms. Including the effect of interactions between atoms, a Yang monopole could turn into a much broader range of topological defects. In the second part of this talk, I will show that adding momentum or angular momentum transfer to these cyclically coupled states, one realizes synthetic Hall cylinder or torus, which could be threaded by a net effective magnetic field through its surface. Such a synthetic Hall cylinder, of which the topology is drastically different than a ribbon, gives rise to a periodic lattice in real dimensions, in which the periodicity of the density modulation of atoms fractionalizes that of the Hamiltonian. I will further highlight the effect of topology by gluing two synthetic Hall cylinders together. In certain conditions, localization may emerge. If time permits, I will briefly discuss the interaction effects.

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