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Singular loops and their non-Abelian geometric phases in ultracold spin-1 atoms BHARATH H. M., MATTHEW BOGUSLAWSKI, MARY-ROSE BARRIOS, LIN XIN, DENIZ KURDAK, MICHAEL CHAPMAN, Georgia Inst of Tech — Non-Abelian and non-adiabatic variants of Berry's phase have been pivotal in the recent advances in holonomic quantum gates, while Berry's phase itself is at the heart of the study of topological phases of matter. Here we use ultracold atoms to study the unique properties of spin-1 geometric phase [1]. The spin vector of a spin-1 system, unlike that of a spin-1/2 system, can lie anywhere on or inside the Bloch sphere representing the phase space. This suggests a generalization of Berry's phase to include closed paths that go inside the Bloch sphere. In [2], this generalized geometric phase was formulated as an SO(3) operator carried by the spin fluctuation tensor. Under this generalization, the special class of loops that pass through the center, which we refer to as singular loops, are significant because their geometrical properties are qualitatively different from the nearby non-singular loops, making them akin to critical points of a quantum phase transition. Here we use coherent control of ultracold 87Rb atoms in an optical trap to experimentally explore the geometric phase of singular loops in a spin-1 quantum system [1]. [1] H. M. Bharath, M. Boguslawski, M. Barrios, Lin Xin and M. S. Chapman, arXiv:1801.00586 [2] H. M. Bharath, arXiv:1702.08564

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