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Ultra-low-loss optical fiber cavities for applications in quantum information processing MANUEL UPHOFF, MANUEL BREKENFELD, DOMINIK NIEMIETZ, STEPHAN RITTER, GERHARD REMPE, Max Planck Institute of Quantum Optics, Garching, Germany — Single atoms strongly coupled to optical cavities are well suited as light-matter interfaces at the single photon level. The strength of the coupling is inversely proportional to the square root of the mode volume of the cavity, which depends on the radius of curvature of the mirrors. We report on the fabrication of near-spherical surfaces with small radii of curvature on the end facets of optical fibers using a CO_2 laser at 9.3 μm wavelength. The surfaces are coated with a commercial, highly reflective, dielectric coating. Cavities built from two of these fibers show a finesse of up to 190000. Due to the small radii of curvature and the high finesse of these cavities, deviations from the paraxial approximation become relevant. This results in a frequency splitting of polarization eigenmodes depending on the eccentricity of the mirrors. Our analytic model that explains this effect is in excellent agreement with our measurements. This allows for the control of the frequency splitting by the geometry of the mirror surfaces. Our results confirm the great prospects of laser-machined cavities for experiments in quantum information processing. The possibility of implementing a quantum repeater node based on our cavity technologies will also be discussed.

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