Hyperfine level structure in nitrogen-vacancy centers near the ground-state level anticrossing

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Energy levels of the nitrogen-vacancy centers in diamond were investigated using optically detected magnetic-resonance spectroscopy near the electronic ground-state level anticrossing (GSLAC) at an axial magnetic field around 102.4 mT in diamond samples with low (1 ppm) and high (200 ppm) nitrogen concentration. By applying microwaves in the frequency ranges from 0 to 40 MHz and from 5.6 to 5.9 GHz, we observed transitions that involve eigenstates mixed by the hyperfine interactions. We developed a theoretical model that describes the level mixing, transition energies, and transition strengths between the ground-state sublevels, including coupling to the nuclear spin of the NV center's 14N nucleus. The calculations were combined with the results from a fitting procedure that extracted information about the polarization of nuclear spin from the experimental curves using the model. These results are important for the optimization of experimental conditions in GSLAC-based applications, e.g., microwave-free magnetometry and microwave-free nuclear-magnetic-resonance probes.