

09,11

Quadrupole-assisted ESEEM of V_B^- in hBN in the canonical high-field (3T) orientation

© G.V. Mamin¹, E.V. Dmitrieva^{1,¶}, P.A. Kosach¹, V.A. Soltamov²

¹ Institute of Physics, Kazan Federal University,
Kazan, Russia

² Lehrstuhl für Theoretische Materialphysik, Universität Paderborn,
Paderborn, Germany

¶ E-mail: dev600@mail.ru

Received July 15, 2026

Revised August 3, 2026

Accepted August 18, 2026

The negatively charged boron vacancy (V_B^-) in hexagonal boron nitride (hBN) is a well-established optically addressable spin defect in a van der Waals host, relevant for coherent spin dynamics, electron–nuclear interactions in two-dimensional materials, and atomically thin quantum sensing. We study electron spin echo envelope modulation (ESEEM) in this system using W-band Hahn-echo measurements at $B_0 \approx 3.2$ T, aligned along the hexagonal c -axis which is the principal axis of the V_B^- zero-field-splitting **D**-tensor. In this canonical high-field orientation, the electron–nuclear spin Hamiltonian is naturally secular, and the hyperfine (HF) interaction with the in-plane nearest-neighbor ^{14}N nuclei is reduced mainly to its longitudinal projection along **B**₀. First-order ESEEM is therefore expected to be suppressed because the transverse pseudo-secular HF terms vanish by symmetry. We show that this expectation is incomplete because the nearest-neighbor ^{14}N nuclear quadrupole (NQ) interaction axis lies approximately in the basal plane, nearly orthogonal to the field-defined quantization axis. The relatively large NQ coupling mixes the nuclear Zeeman states, while the longitudinal HF shift makes this mixing electron-spin dependent. The resulting non-commuting nuclear Hamiltonians produce finite Hahn-echo modulation even in the canonical high-field regime.

Keywords: optically addressable spin defects in solids, boron nitride.

Full text of the paper will appear in journal SOLID STATE.