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Polarization dynamics of triaxial modulation SERF atomic magnetometers

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Triaxial spin-exchange relaxation-free (SERF) atomic magnetometers (AMs) provide more comprehensive magnetic field information in bio-magnetic measurements, effectively improving the accuracy of magnetic source reconstruction. Typically, the triaxial AM is considered to be three independent orthogonal single-axis AMs, but the interaction of the triaxial modulation is ignored. This study established polarization dynamics under triaxial modulation, providing a theoretical model for triaxial AMs. Based on the perturbation iteration theory, the modulation field along the cross-axis is regarded as a perturbation term. Subsequently, the polarization dynamics model is established by summing the steady-state and multiorder perturbations of the triaxial polarization projections. Based on the proposed model, we discovered an optimal modulation coefficient formula for the triaxial SERF AM, replacing the constant optimal coefficient used when treating it as three independent single-axis AMs. The proposed optimal modulation coefficient exhibited a 12% improvement in response relative to the conventional coefficient. The proposed polarization dynamic model is beneficial for further investigation of triaxial SERF AMs and contributes to the improvement of their sensitivity.

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