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Magnetic Field Noise from High Permeability Magnetic Shields for Precision Measurements S.-K. LEE, S.J. SMULLIN, T.W. KORNACK, M.V. ROMALIS, Princeton University — High permeability magnetic shields often generate magnetic field noise that can limit the sensitivity of precision measurements. We show that calculations based on the fluctuation-dissipation theorem allow evaluation of magnetic field noise, either by current or spin fluctuations, from high permeability metals and ferrites over a broad frequency range. For example, the noise spectrum of a mu-metal shield generally exhibits three distinct frequency dependent behaviors: low frequency 1/f spin noise, white noise due to Johnson noise current, and high frequency roll-off due to self-shielding. To reduce the effect of Johnson noise current, we built a multi-layer shield for a potassium SERF atomic magnetometer using ferrite for the innermost layer. We found that the white noise was reduced from about 20 fT/Hz$^{1/2}$, as expected for an all-mu metal shield, to 0.75 fT/Hz$^{1/2}$, limited by laser noise. The low frequency 1/f noise agreed well with calculation based on the measured complex permeability of the ferrite. Our method can be used to identify low noise shielding materials for further suppression of shield-generated noise for compact atomic magnetometers.

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