Single-Beam All-Optical Nonzero-Field Sensor for MEG

M. Petrenko[1], A. Pazgalev[1], and A. Vershovskii[1]

[1]*Ioffe Institute, 194021 St. Petersburg, Russia.*

We present a magnetometric sensor scheme, which uses a single laser for optical pumping, magnetic resonance (MR) excitation, and MR probing. MR is excited by the modulation of circularly polarized component of the beam, and detection is achieved in a quantum nondestructive manner by the linearly polarized component. This allows us to significantly simplify the Bell-Bloom scheme [1], while retaining its sensitivity [2].

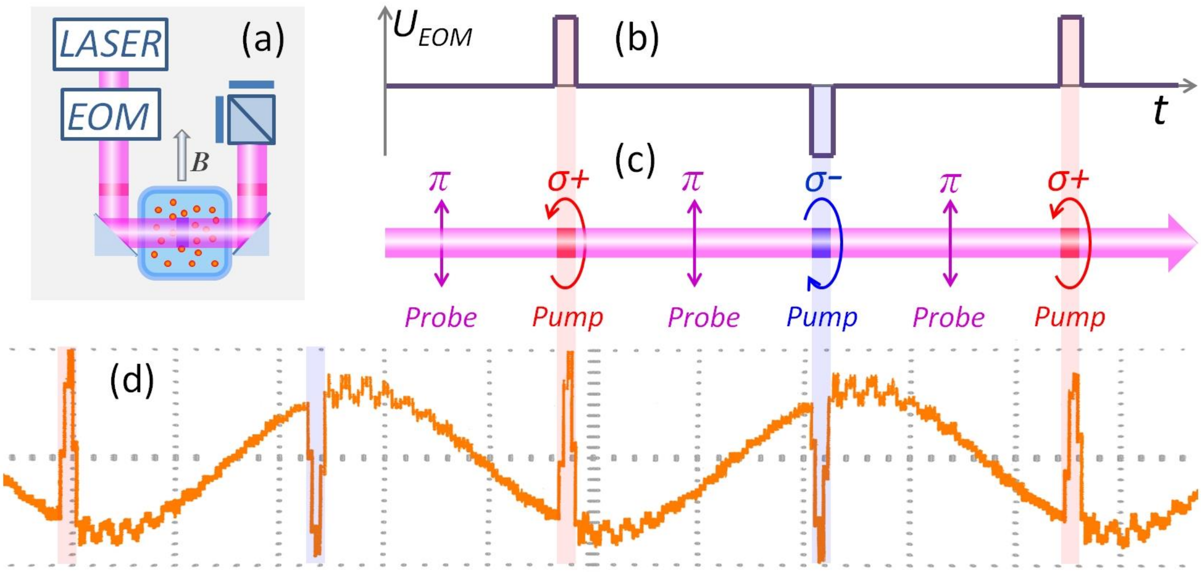

Figure 1: (a) Simplified setup diagram; (b) EOM control voltage; (c) one modulation period: $\sigma^{\pm}$ – circular polarizations, π – linear polarization; (d) Larmor precession signal.

A single beam is tuned to a frequency close to the $F = I–½ \leftrightarrow F' = I±½$ transitions of the $S_{1/2}$ state of an alkali metal (in our work, we use Cs); this beam depletes the $F = I–½$ level, and populates and strongly polarizes the $F = I+½$ level, forming the stretched state. Therefore the π-component of the beam, which we use for probe, mainly detects the MR at a level from which it is detuned by ~9 GHz. This provides the appropriate conditions for nondestructive quantum detection; thus, we achieve near-optimal conditions for both pumping and probing. Fig.1 shows a version that uses high duty cycle pulse pumping, which makes it possible to further reduce the MR width.

References

[1] W. Bell and A. Bloom, Phys. Rev. Lett. **6**, 280 (1961).

[2] M.V. Petrenko, A.S. Pazgalev, and A.K. Vershovskii, Phys. Rev. Applied **15**, 064072 (2021).