Helium-3 magnetometers for high fields

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While low magnetic fields (< 10^{-2} T) can be measured extremely precisely (ca. 10^{-13}) using SQUID or SERF, nuclear magnetic resonance (NMR) offers the highest precision at high fields. Moreover, the highest metrological accuracy is achieved through continuous measurements of frequencies. This demands a sample with long coherence times, as it is the case for motionally averaged signals of gases. A state that requires only a few millibar of the gas, hence necessitates hyperpolarization of the nuclear spins even at high fields. For this reason, ^{3}He is the ideal candidate due to its ability to be hyperpolarized — either via metastability optical pumping (MEOP) [1] or the PAMP-effect [2]. Furthermore, it shows only minimal interactions with the environment and its gyromagnetic ratio has been determined independently using Penning-traps [3]. Another requirement to obtain such extremely long lasting signals (T_2* times in the order of 100 – 200s) the sample has to be kept in suitable containers to minimize susceptibility effects [4] and allow even for absolute field measurements [5].

While low-pressure and hyperpolarized ^{3}He enables extreme precision magnetometry (< 10^{-12}), we recently also produced high pressure (up to 50 bar) ^{3}He samples for applications in which optical polarization is impractical. Such thermally polarized samples can serve as very simple and robust NMR-magnetometers and may be used over a very broad temperature range (1-300 K). Their production and strategies to adjust T_1 for rapid sampling are presented for a temperature range from 5 to 300 K. [6]

Taken together, ^{3}He-magnetometers have the potential to become the new standard for high precision magnetometry at high magnetic fields.

Reference:

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