Relaxation time optimization of nuclear magnetic resonance magnetometer based on Taguchi method

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Optically-pumped atomic magnetometers based on Nuclear Magnetic Resonance(NMR) principle [1] have several advantages, such as wide measurement range, wide bandwidth and high sensitivity. It can be used in occasions with large ambient magnetic field, including fundamental science and geomagnetic navigation. Nuclear relaxation time is an indication of magnetometer performance. The longer the nuclear relaxation time is, the higher the accuracy of frequency measurement of NMR magnetometer will be. However, NMR magnetometer is a multi-parameter system and the interaction of parameters complicates the optimization of relaxation time. We built a magnetic field measurement device based on the NMR principle, as shown in Figure 1(a) and use Free Induction Decay (FID) signal to acquire relaxation time. Based on that, Taguchi method is used to optimize the nuclear relaxation time. The Signal to Noise (S/N) main effect obtained by Taguchi method is shown in Figure 1(b). The intensity of pump light has the greatest influence on relaxation time, followed by temperature, while the magnitude of z-direction magnetic field has the least effect on that. When the temperature is 100 °C, z-direction magnetic field is 12000 nT and the intensity of pump light is 30 mW/cm^2, the nucleon relaxation time reaches 10.9 s. The relaxation time can be further increased by optimizing the pressure in the cell.

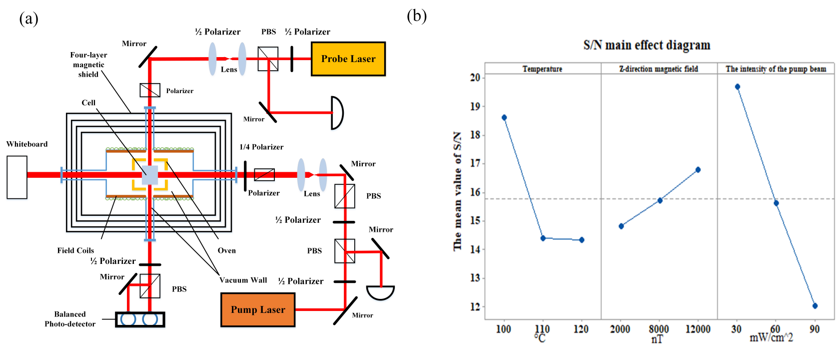

Figure 1. (a) Experimental setup of NMR magnetometer using Rb and ^{129}Xe. (b) The S/N main effect obtained by Taguchi method.

[1] M.Bulatowicz and M.Larsen, Compact atomic magnetometer for global navigation (NAV-CAM), 2012 IEEE on Position Location and Navigation Symposium, **1088-1093**, (2012).