A sensitive atomic magnetometer

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Magnetometers are widely used to measure the strength and direction of the magnetic field. Recently, it is reported that high sensitive atomic magnetometers are capable of measuring magnetic fields below 10^{-15}T. This kind of atomic magnetometer is based on a small alkali vapor cell, so it is capable of making into very small volume. With the advantage of sensitive and small size, I think this kind of magnetometer will be widely used soon.

There are several kinds of structure based on this magnetometer. Here I am going to introduce the structure in "A new spin on magnetometry" on "Nature" by Dmitry Budker. In this paper, the author gives an image (see fig.1) and tells us how it works: "First, the atoms are optically pumped and adopt the polarization of the pumping laser beam. Second, the magnetic field to be measured causes the atomic polarization to evolve: in the simplest case, the atomic magnetic moment precesses around the direction of the magnetic field. Finally, the evolution of the polarization is probed using laser light — either from the same laser beam that produced the pumping, or from a separate source." Actually, these three stages occur simultaneously.

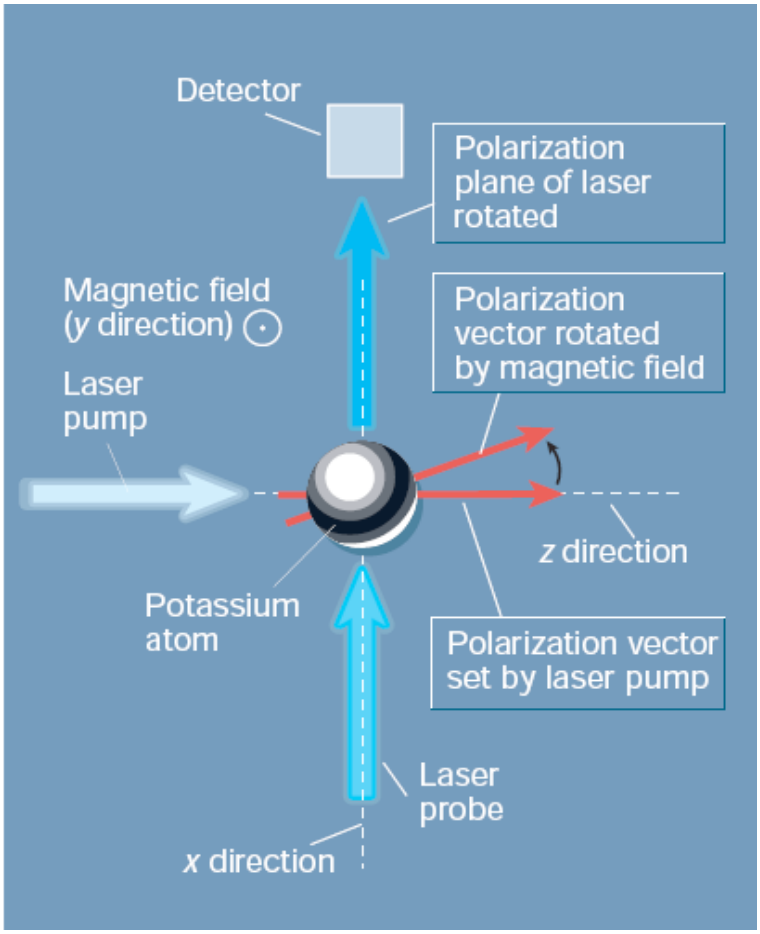
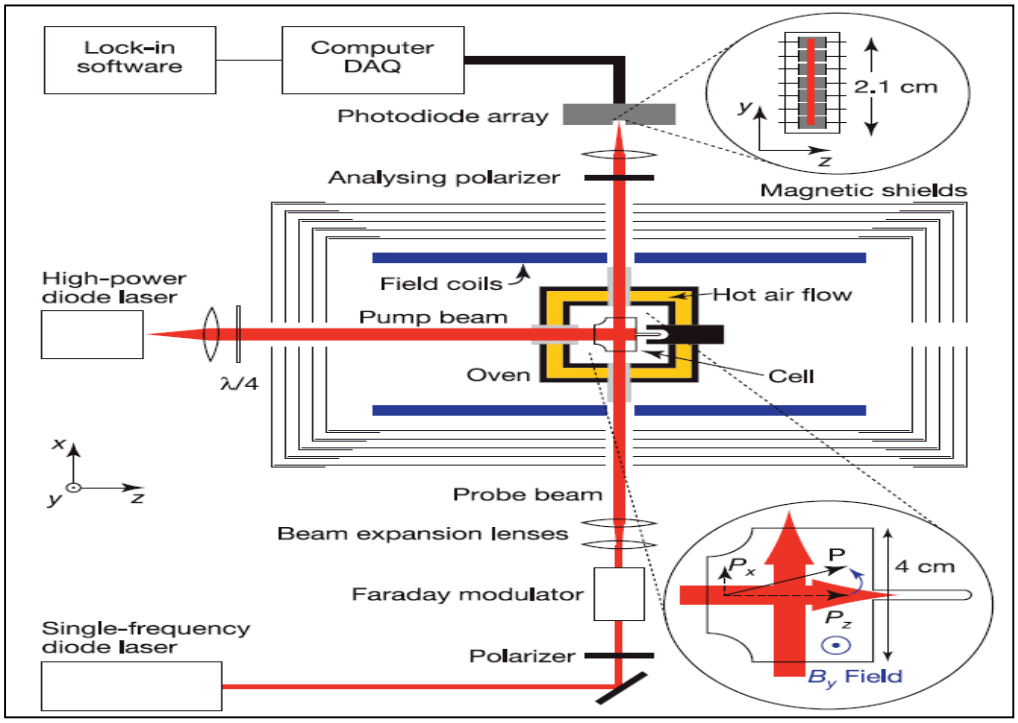


Fig 1

The sensitive of the magnetometer is given by $\delta B = \frac{1}{\gamma\sqrt{nT_2Vt}}$, where n is the density of atoms, γ is their gyromagnetic ratio, T_2 is the transverse spin relaxation time, V is the cell volume, and t is the measurement time. So in order to improve the sensitivity of the magnetometer, the most important way is to make T_2 as large as possible. There are several ways being proved to get long spin relaxation time. One is to use the cells whose inner walls are coated with paraffin, which is capable to reduce the collisions between atoms and the cell walls. The other is to add a dense

helium buffer gas to the alkali vapor cell, which to slow down the diffusion of the alkali atoms.

In a real experimental set-up, there are lots of techniques involved (see fig. 2), such as how to make a circularly polarized light, how to modulate the light and so on.



Reference:

- Dmitry Budker, *Nature* 422, 574-575 (2003)
- D.Budker, *Review of Modern Physics*, 74,1153 (2002)
- Kominis, I. K., Kornack, T. W., Allred, J. C. & Romalis, M. V. *Nature* **422,** 596–599 (2003)