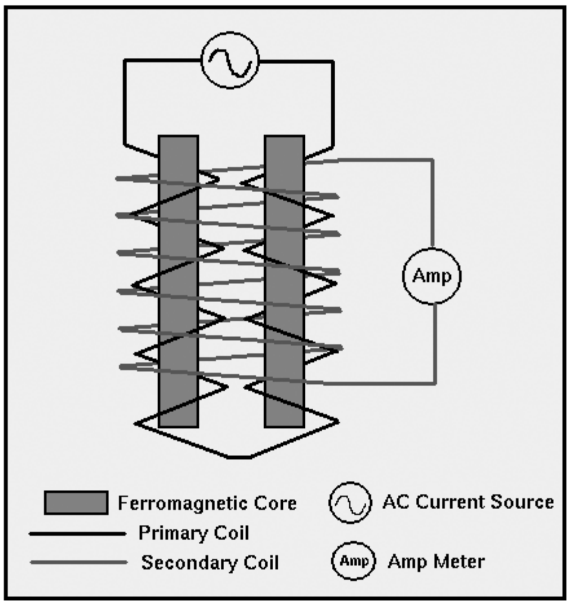
Classification of Vector magnetometer sensors according to the materials used

Introduction

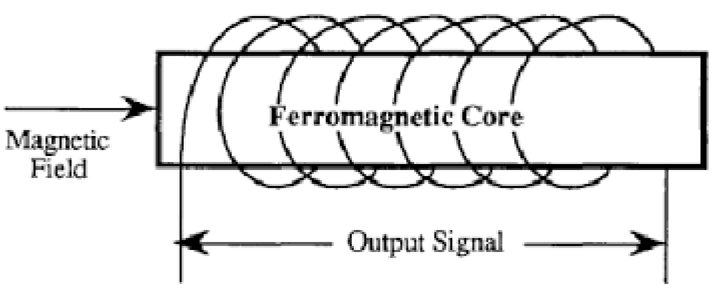
An outline investigation into the possibility of modern magnetometes to be responsible for giving us a distorted and fault field view geometry of magnetism.

Types of Ferromagnetic Vector Magnetometers (sensors)

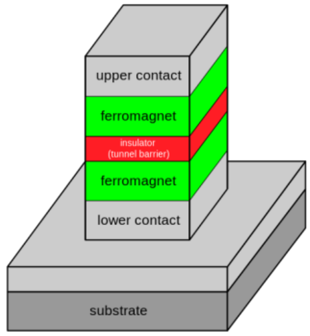
- **Fluxgate** . Uses ferromagnetic cores

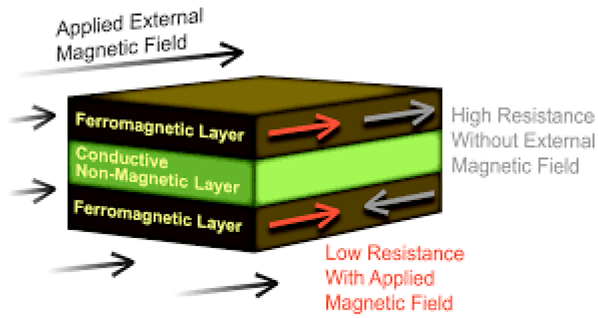


- **Search coil**. Uses ferromagnetic core



- **Magnetoresistive**. Use ferromagnetic metals or semiconductor-magnetic metal hybrids (ferromagnetic)

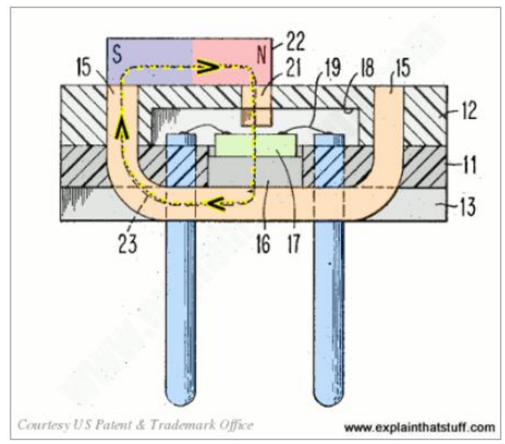




- **Hall effect sensors**. Semiconductor using a ferromagnetic metal field induction circuit

Artwork: How a typical Hall sensor is packaged. Magnetic fields can be very small, so we need our detectors to be as sensitive as possible, and here's one way to achieve that. The Hall chip itself (green, 17) is mounted on an iron carrier plate (gray, 16) sandwiched inside two molded plastic sections (gray, 11, 12). The chip is wired by leads (19) to terminal pins (blue) by which it can be connected into a circuit. But the really important parts are two soft iron "flux concentrators" (orange, 15, 21), which make the device very much more sensitive. When you place a magnet (22) near the sensor, these concentrators allow the magnetic flux (the "density" of magnetism produced by the magnetic field) to flow around a continuous loop through the Hall chip, producing either a positive or negative voltage. If the magnet slides over to the other side of the sensor, it produces the opposite voltage. Artwork from US Patent 3,845,445: Modular Hall Effect Device by Roland Braun et al, IBM Corporation, October 29, 1974, courtesy of US Patent and Trademark Office.

Like 41
G+
Tweet

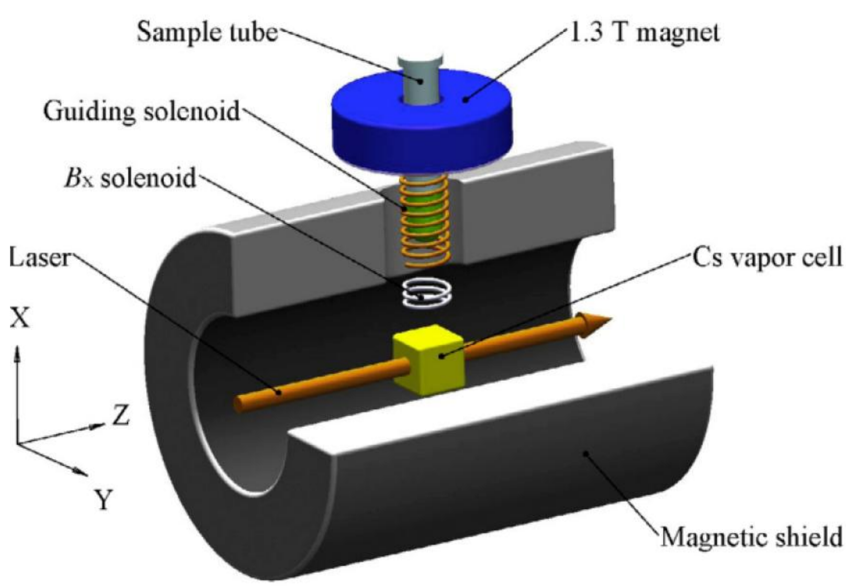


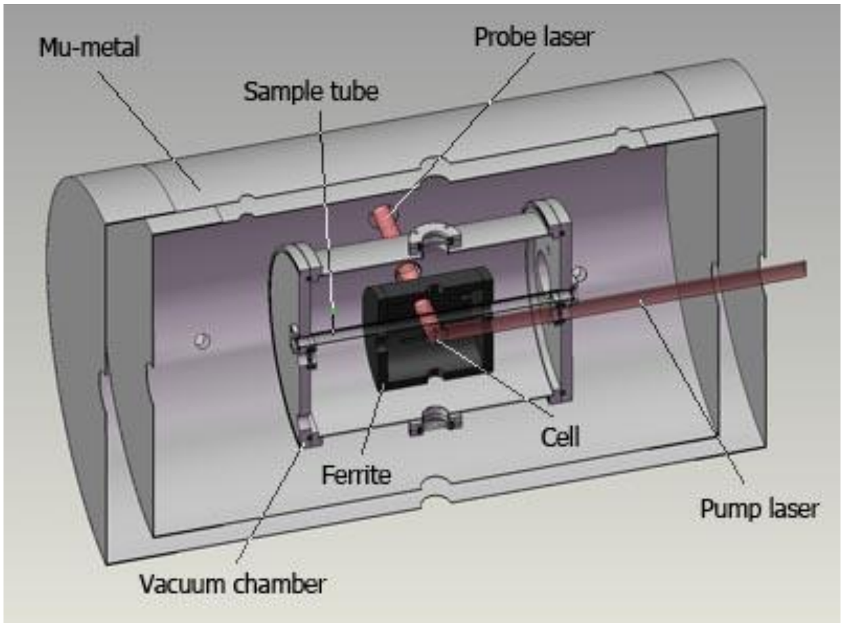
Find out more

- **Iron filings. Old classical Faraday experiment. This is now an outdated method and used only by hobbyists and for basic education.**

Types of non-ferromagnetic Vector Magnetometers (sensors)

- **SERF**. Uses paramagnetic sensor materials usually potassium K or Cesium Cs vapor. These atomic magnetometers need to be heavily shielded against magnetic noise. Sensor is heavily magnetic shielded in a Mu-metal and ferrite core shield embodiment. *Not sure how these strong ferromagnetic materials affect the sampled field in the sensor.*

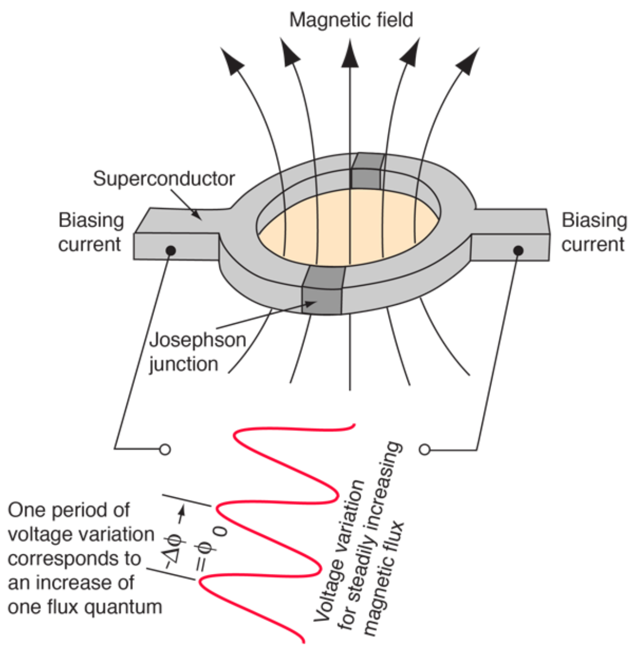




http://physics.princeton.edu/romalis/magnetometer/

http://zhougroup.org/index.php?z=spage&c=index&a=18

- **SQID. Uses superconductors (strongly diamagnetic) materials and Josephson Junctions.**



https://aip.scitation.org/doi/10.1063/1.5001390

https://arxiv.org/ftp/arxiv/papers/1708/1708.07302.pdf [2]

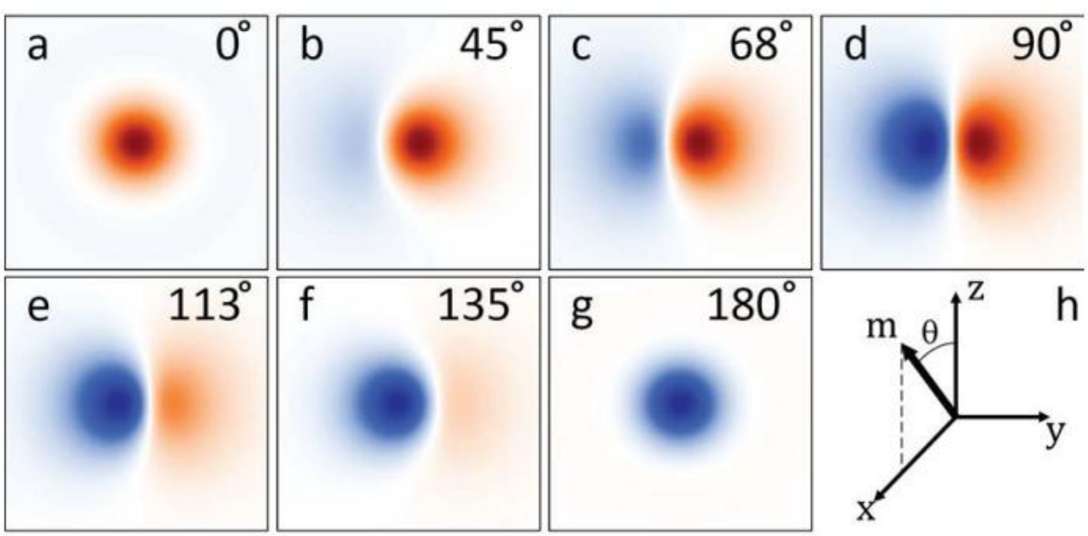


Figure 4. (a-g) Simulated magnetic field intensity images of dipoles with changing inclination angle *θ* with the *z*-axis. (h) Coordinate system of (a-g).

Figure 4d also shows how SSM images in-plane magnetic moment. In order to close the field lines, the magnetic field must rotate through the out-of-plane direction to reverse and close the loop. This is why, in the in-plane case of Figure 4d, the magnetic field signal is strongest a small distance away from the point-dipole.

Figure 1 See fig.4d above. Squid imaging of point dipole magnet (side view). Notice the two separated monopolar fields also shown by the ferrolens. There is no direct flux going from one pole to the other. White line in the middle is the domain wall of the dipole magnet. The angle indicated 90 ° shows that the SQUID sensor is centered directly above the dipole magnet (perpendicular). **[2]**

Note: The above fig.1 is a snapshot taken from reference [2] paper. Notice at the yellow highlighted text how the authors of this paper try to explain this "puzzling separation" of the polar fields shown in their squid simulation. Even if you curve the field lines out-of plane to return to the other pole as they explain, the separation in the middle would still exist and cannot be discarded since the above fig4d represents a 2D in half dissection of the actual 3D dipole field measured with the SQUID sensor!!...

- **Ferrolens or Ferrocell**. Uses superparamagnetic thin film of heavily diluted (less than 1%) Fe_3O_4 magnetite nanoparticles ferrofluid together with surfactant solution encapsulated inside and optical lens and artificial lighting for visualizing in real-time magnetic fields. Although a quantum optic magnetic field imaging device or quantum magnetic flux viewer under specific modifications and methodology it could be used also as a magnetic field strength mapper and magnetometer [1].

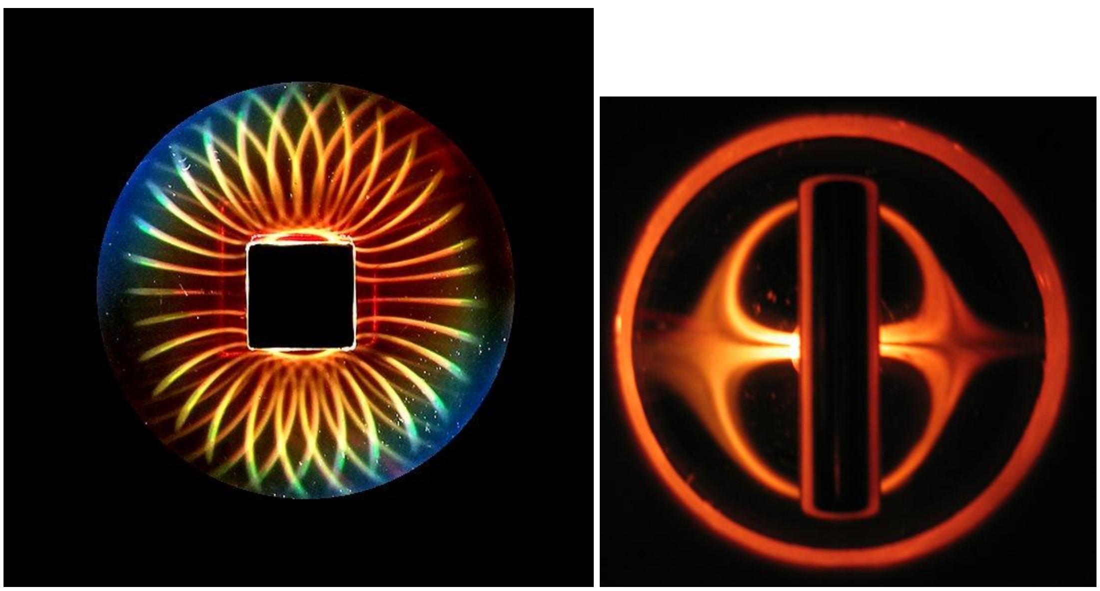
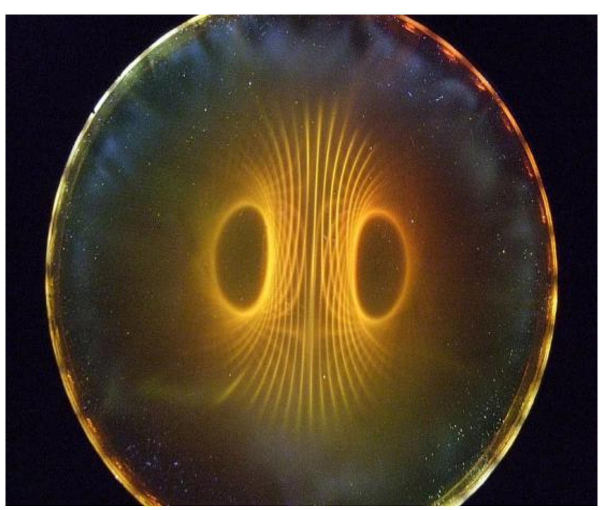
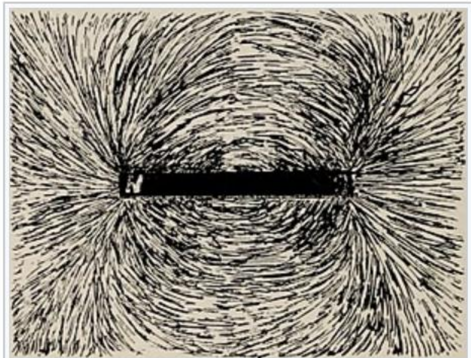


Figure 2 Dipole magnet field views taken with the ferrocell. All pictures show clearly the separation of the two polar fields.



Note: The only other magnetic field sensor in this report which agrees with the ferrocell is the SQUID. All other sensors apart the SERF sensor which I couldn't find any imaging photos, display the classical view of the field of a dipole magnet with the flux going from North pole to South pole joining the two poles.



Classical ferromagnetic iron filings visualization method of the field of a magnet.

Figure 3

Conclusion

This investigation hereby presented yields that ferromagnetic magnetometer sensors whenever used present a different field geometry than other non-ferromagnetic sensors for magnetic field mapping and imaging applications. Specifically, ***ferromagnetic sensors*** give a **uniform spherical** geometry (fig. 3) of a dipole magnetic field ***whereas non-ferromagnetic sensors and methodologies like the SQUID or the Ferrolens, depict a two hemispherical joined geometry (fig. 1&2) of the two polar fields on the magnet clearly separated by its Bloch domain wall!!...***

This leads us into the conclusion that, inescapably, that an intrinsic and inherent property of the material used in a magnetometer sensor somehow interferes and distorts the actual magnetic field geometry assuming all magnetometer types examined have adequate sensitivity and spatial resolution. The main suspect we believe are the ferromagnetic magnetometers for reasons we will analyze and prove in one of our next publications.

References

[1] S.S. Nair, S. Rajesh, V.S. Abraham, M.R. Anantharaman, Ferrofluid thin films as optical gaussmeters proposed for field and magnetic moment sensing, Bull. Mater. Sci. 34 (2011) 245–249. doi:10.1007/s12034-011-0059-7.
https://link.springer.com/content/pdf/10.1007%2Fs12034-011-0059-7.pdf

[2] TI - Analysing magnetism using scanning SQUID microscopy - PT - Journal Article DP - 2017 TA - Review of Scientific InstrumentsPG - 123706 VI - 88IP - 12 AID - 10.1063/1.5001390 [doi]4099 - 4100
https://aip.scitation.org/doi/full/10.1063/1.5001390 SO - Review of Scientific Instruments December 2017 88(12):