

We claim:

1. A high sensitivity atomic magnetometer comprising:
 - a) a sensing cell containing a mixture comprising an alkali metal vapor and a buffer gas, wherein the sensing cell is exposed to a background magnetic field lower than a predetermined value;
 - b) means for increasing the magnetic polarization of the alkali metal vapor thereby increasing the sensitivity of the alkali metal vapor to a low intensity magnetic field;
 - c) magnetizing means for imposing a magnetic field on a volume of space comprising the sensing cell;
 - d) means for probing the magnetic polarization of the alkali metal vapor, the probing means providing an output from the alkali metal vapor, the output comprising characteristics related to the low intensity magnetic field; and
 - e) measuring means wherein the measuring means receives the output, determines the characteristics of the low intensity magnetic field, and provides a representation of the low intensity magnetic field; wherein the limit of detectability of the atomic magnetometer is about $10 \text{ femtotesla (Hz)}^{-1/2}$.
2. The atomic magnetometer described in claim 1 further comprising magnetic shielding enclosing a region of space comprising the magnetizing means and the sensing cell.
3. The atomic magnetometer described in claim 1 wherein the predetermined value is about 10^{-8} tesla.
4. The atomic magnetometer described in claim 1 wherein the density of the alkali metal in the vapor is about 10^{11} cm^{-3} or greater.
5. The atomic magnetometer described in claim 1 wherein the alkali metal is chosen from the group consisting of sodium, potassium, rubidium and cesium.
6. The atomic magnetometer described in claim 1 wherein the alkali metal is potassium.
7. The atomic magnetometer described in claim 1 wherein the buffer gas comprises a noble gas.
8. The atomic magnetometer described in claim 1 wherein the buffer gas comprises one or more isotopes of helium.
9. The atomic magnetometer described in claim 1 wherein the pressure of the buffer gas is in the range from about 1 atm to about 10 atm.
10. The atomic magnetometer described in claim 1 wherein the buffer gas further comprises nitrogen gas.
11. The atomic magnetometer described in claim 1 wherein the sensing cell is maintained at a temperature effective to provide an alkali metal vapor at a density greater than about 10^{11} cm^{-3} .
12. The atomic magnetometer described in claim 1 wherein the volume of the sensing cell is less than about 200 cm^3 .
13. The atomic magnetometer described in claim 1 wherein the means for increasing the magnetic polarization of the alkali metal vapor comprises a first radiation generating means that generates a first beam of radiation illuminating the alkali metal vapor, the first beam being effective to increase the magnetic polarization of the alkali metal vapor.
14. The atomic magnetometer described in claim 13 wherein the first radiation generating means comprises a first laser device.
15. The atomic magnetometer described in claim 13 wherein the first radiation generating means further comprises a first optical polarizing means that polarizes the first beam of radiation.

16. The atomic magnetometer described in claim 13 wherein the first radiation generating means comprises a first optical polarizing means that imposes linear polarization on the first beam of radiation.
17. The atomic magnetometer described in claim 13 wherein the first radiation generating means comprises a first optical polarizing means that imposes circular polarization on the first beam of radiation.
18. The atomic magnetometer described in claim 13 wherein the first radiation generating means further comprises a first modulator that modulates the first beam of radiation by a first modulation function.
19. The atomic magnetometer described in claim 1 wherein the probing means comprises a second radiation generating means that generates a second beam of radiation traversing the alkali metal vapor and wherein the output comprises the second beam after it traverses the vapor.
20. The atomic magnetometer described in claim 19 wherein the second radiation generating means comprises a second laser device.
21. The atomic magnetometer described in claim 19 wherein the second radiation generating means further comprises a second optical polarizing means that polarizes the second beam of radiation.
22. The atomic magnetometer described in claim 21 wherein the second radiation generating means comprises a second optical polarizing means that imposes linear polarization on the second beam of radiation.
23. The atomic magnetometer described in claim 21 wherein the second radiation generating means comprises a second optical polarizing means that imposes circular polarization on the second beam of radiation.
24. The atomic magnetometer described in claim 19 wherein the second radiation generating means comprises a second modulator that modulates the second beam of radiation by a second modulation function.
25. The atomic magnetometer described in claim 1 wherein the magnetizing means provides a probing magnetic field in one, two, or all three of the orthogonal directions, x, y, and/or z.
26. The atomic magnetometer described in claim 1 wherein the magnetizing means provides a probing magnetic field modulated by a third modulation function.
27. The atomic magnetometer described in claim 1 wherein the measuring means comprises an output detecting means that provides a signal comprising characteristics related to the low intensity magnetic field, and a signal processing means for receiving the signal and providing the representation.
28. The atomic magnetometer described in claim 27 wherein the output detecting means comprises radiation detecting means that detects a second beam of radiation output from the alkali metal vapor.
29. The atomic magnetometer described in claim 28 further comprising a third optical polarizing means placed between the sensing cell and the radiation detecting means.
30. The atomic magnetometer described in claim 29 wherein the third optical polarizing means comprises a linear polarization analyzer.
31. The atomic magnetometer described in claim 29 wherein the third optical polarizing means comprises a circular polarization analyzer.
32. The atomic magnetometer described in claim 28 wherein the radiation detecting means comprises a photodetector, wherein the photodetector provides a signal comprising characteristics related to the low intensity magnetic field.