Auto-Adaptive Statisical Signal Processing Systems for Magnetic Sensors

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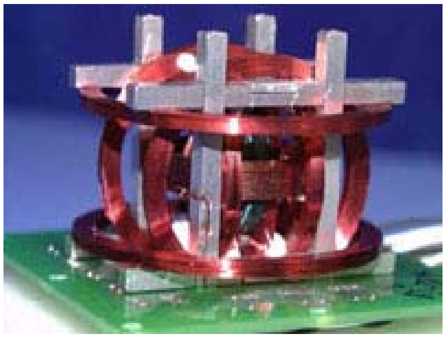
Fluxgate Magnetometers

Fundamentals of operations:
• Magnetic field induces change in current in coils of wire which can be converted to an electrical signal related to the strength of the magnetic field
• External processing allows for this to be converted into position and direction information

Advantages:
• Low cost
• Well-established for military and space applications
• Robust construction
• Vector input – contains position and direction information

Disadvantages:
• Low sensitivity
• Highly dependent on orientation of magnetometer – sensitive to marine pitch and roll
• High power consumption
• Long warm-up time



Photograph of coil arrangement in sample fluxgate magnetometer system

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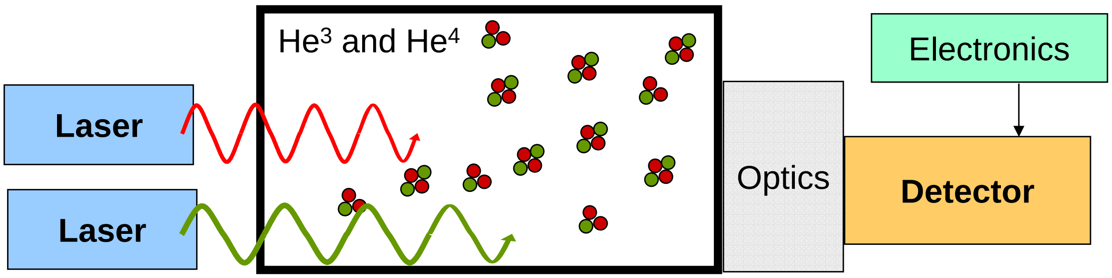
Atomic magnetometers



Fundamentals of Operation

- Pump laser beam of proper wavelength excites He atoms
- Spin precession of excited states influenced by an external magnetic field
- Transmitted effect on polarized transmission beam can be monitored to get a signal proportional to magnetization

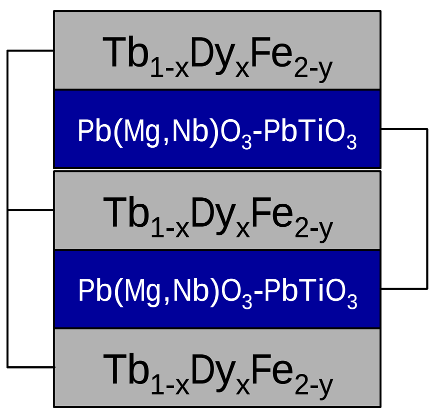
Advantages

- Highest Sensitivity – longest detection ranges
- Established use in airborne MAD sensors

Disadvantages

- Scalar magnetometer – need 4 for gradiometric input
- Power Consumption
- Size and configuration
- High cost and complexity

Magnetoelectric Magnetometers



Multilayers

Schematic of the multilayered multiferroic construction which may be used in future iterations of low-power military magnetic sensors.

Fundamentals of operations:

- Multiferroic laminated multilayered system consists of ferroelectric material and magnetically responsive material
- External magnetic field introduces magnetic response, which is transferred to the ferroelectric at the layer interface and give electrical signal proportional to magnetic field

Advantages:

- Low cost
- Low power
- Simple system design

Disadvantages:

- Less developed technology for sensor applications
- Lower sensitivity than atomic and SQUID magnetometers

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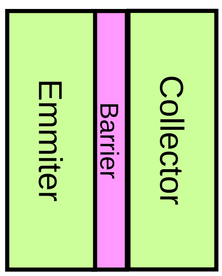
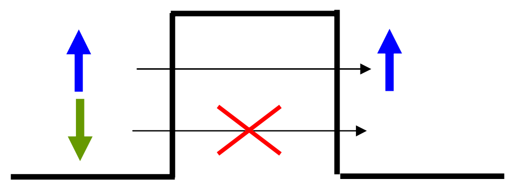
Spin-Based Tunneling Devices





<u>Fundamentals of Operation</u>

- Microelectronic devices based on electrical transport between two magnetic materials
- Difference in tunneling between two different spin configurations leads to difference in electrical resistance
- Magnetic interactions effect local spin configurations which can be measured

<u>Advantages</u>

- Small Size
- Low power consumption
- Low cost
- Instant on/off

<u>Disadvantages</u>

- Moderate sensitivity
- Large scale device applicability and sensitivity not well-explored

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Brainlike – Georgia Tech Future Directions

Device Optimization + Processing Improvements

Sensor Performance

- Single-phase Multiferroic Sensors
- Diluted Magnetic Semiconductor Nanowires
- Radiation-hard nitride based infrared emitters and detectors for atomic magnetometry
- Spin polarized emitters and detectors

- Brainlike processing improvement
- Multi-sensor data integration and comparison
- Real-world algorithm test and development

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