# Research on the Magnetic Field Generator of Overhauser Magnetic Sensor

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Magnetic field generator is an essential part of automatic magnetic measurement. Based on the Biot-Savart law, we establish mathematical models of magnetic distribution for different coil systems and discuss their magnetic intensity and homogenous area. We propose a sphere coil to generate a larger homogenous magnetic space with a smaller geometric size that improving the space utilization.

## BACKGROUND

Special magnetometers, designed to get additional geomagnetic elements, are with composite measurement structure.

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Combination of scalar magnetometer and magnetic field generator

## CHALLENGE

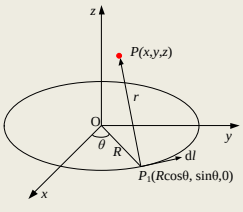
- Large size of present magnetic field generators
- Bad balance between homogeneity and magnetic intensity

## MAGNETIC THEROY

- Biot-Savart law

$$dB=\frac{\mu_0}{4\pi}\frac{Idl\times r}{r^3}=\frac{\mu_0}{4\pi}\frac{I|dl|\times|r|\times\sin\theta}{r^3}=\frac{\mu_0}{4\pi}\frac{I|dl|\times\sin\theta}{r^2}$$

- Current loop




$$B_x=\frac{u_0NI}{4\pi R}\int_0^{2\pi}\frac{\alpha\cos\theta d\theta}{[1+\alpha^2+\beta^2-2\beta\cos\theta]^{3/2}}$$

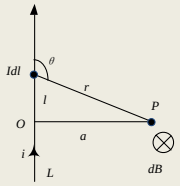
$$B_y\equiv 0$$

$$B_z=\frac{u_0NI}{4\pi R}\int_0^{2\pi}\frac{(1-\beta\cos\theta)d\theta}{[1+\alpha^2+\beta^2-2\beta\cos\theta]^{3/2}}$$

$\alpha=\frac{x}{R}$ $\beta=\frac{z}{R}$

Magnetic distribution

- Current wire




$$B=\int_L dB=\frac{\mu_0}{4\pi}\int_L\frac{Idl\sin\theta}{r^2}$$

$$dl=\frac{a}{\sin^2\theta}d\theta$$

$$B=\frac{\mu_0 I}{4\pi a}(\cos\theta_1-\cos\theta_2)$$

angles between $P$ and the endpoints of current wire

Magnetic distribution

## HOMOGENEITY ANALYSIS

- Square Helmholtz coil and Four square coils

Magnetic intensity and homogenous area of the four square coils are superior to the square Helmholtz coil.

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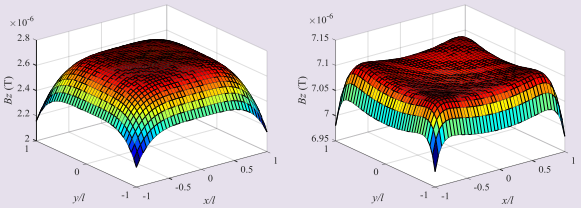
Number of coils ↑ → magnetic intensity ↑, homogenous area ↑



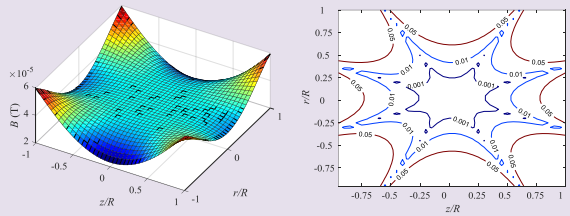

- Proposed sphere coil

Construction: sixteen coaxial equidistant circular coils

Magnetic distribution

$$\left\{\underbrace{B_z(r,z)=B_0[1-0.374\times(\zeta^4-3\zeta^2\rho^2+\frac{3}{8}\rho^4)]}_{\text{axial magnetic}},\underbrace{B_r(r,z)=B_0\times(0.748\zeta^3\rho-0.561\zeta\rho^3)}_{\text{radial magnetic}}\right\}$$

Uniformity $\varepsilon=\frac{B_p-B_0}{B_0}\times 100\%$ $B_p$: magnetic of arbitrary point $P$




Magnetic intensity: higher than four square coils

Homogeneous area: cylinder ($r=0.531R$, $H=1.88R$ at $\varepsilon=1\%$)

## CONCLUSION

- The spatial utilization of magnetic generator improved
- Great potential to miniature the size of magnetometer