A review of the paper EGUsphere-2022-480

Automated Static Magnetic Cleanliness Screening for the TRACERS Small-Satellite Mission

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The magnetic cleanliness program is significant to achieve scientific objectives related to magnetic field measurements. Any magnetic tests are to be carried out for all components and subsystems of engineering and flight models of spacecraft so as to suppress stray magnetic fields. Hence, the authors present an automated magnetic screening apparatus and procedure for the purpose as mentioned above. An object to be tested is put on the center of the magnetically clean plate which can be rotated by a flow of nitrogen. The plate and magnetometers are put in a cube made of mu-metal with very high permeability to magnetically shield them. It is important that not only specialists in magnetic cleanliness but also technicians can carry out such magnetic tests routinely and efficiently.

The subject seems to be appropriate for publication in *Geoscientific Instrumentation, Methods and Data Systems*. Its significance and quality are highly evaluated. However, there are some points to be reconfirmed and clarified. Furthermore, if the software is improved, not only the magnetic dipole moment in an object but also its location can be determined. I do not think that the improvement is very difficult. I therefore require moderate revision. I offer comments below for the authors' consideration of revision.

Line 54, Figure 2, and line 97

It is better to specify the maximum size of an object to be tested. This point is related to an assumed far-field measurement.

Figures 2 and 3

The subplots in Fig. 2 (times series measured by magnetometers at 11 cm and at 17 cm) are identical to the subplots in Fig. 3. This means that the authors can rearrange these figures to one figure.

In the upper-left subplot of Fig. 3, the peak-to-peak amplitude of B_z seems to be about or larger than 4000 nT, but the corresponding periodic amplitude in the upper-right subplot is 3223.3 nT. Is this caused by a flattop window applied to time series? If it is the case, it is better to mention it. By the way, which is better, use of a flattop window or not?

Equation (1)

The subscript m should be specified. Later, m is used as the magnetic dipole moment.

Equations (2) and (3)

The subscript k should be specified.

Equations (4) and (5)

Vectors $\boldsymbol{r}$, $\boldsymbol{\vartheta}$, $\boldsymbol{i}$, $\boldsymbol{j}$, and $\boldsymbol{k}$ should be specified.

" , " between two equations for $\theta = \cdots$ and $\phi = \cdots$ is significant to separate these equations, so that add "comma" in Equation (5).

It is better to use different sign for the inner product of vectors, $\cdot$, and scalar multiplication.

Lines 106–110

"It is important that the object on the plate is centered." I agree with it. However, a magnetic dipole in the object is not necessarily present at the center of the object. In the same sense, how about the hight of magnetometers against the object? In other words, an offset dipole moment should be taken into account. This suggests that the present method may have any defect. To overcome this point, the authors can determine spherical harmonic coefficients up to degree 2.

As the authors understand, if a magnetic dipole moment, $\boldsymbol{M}$, is present at the center (at the origin), a magnetic potential, Ψ, is written as

$$\Psi(r,\theta,\phi) = \frac{\mu_0}{4\pi}\frac{\boldsymbol{M}\cdot\boldsymbol{r}}{r^3},$$

where $\boldsymbol{r}$ is the position vector and (r,θ,ϕ) are the spherical coordinates (it should be noted that definition of θ and ϕ is different from that in the manuscript, in which θ and φ are the dipole's angle from the z-axis and that from the x-axis, respectively), and the magnetic field is expressed as

$$\boldsymbol{B}(r,\theta,\phi) = -\nabla\Psi(r,\theta,\phi).$$

If $\boldsymbol{M}$ is present at $\boldsymbol{r}_0 = (x_0, y_0, z_0)$ which is not very far from the origin, Ψ can be expressed as

$$\begin{aligned}
\Psi(r,\theta,\phi) &= \frac{\mu_0}{4\pi}\frac{\boldsymbol{M}\cdot(\boldsymbol{r}-\boldsymbol{r}_0)}{|\boldsymbol{r}-\boldsymbol{r}_0|^3} \\
&= \frac{\mu_0}{4\pi}\frac{M_x(x-x_0)+M_y(y-y_0)+M_z(z-z_0)}{\{(x-x_0)^2+(y-y_0)^2+(z-z_0)^2\}^{3/2}} \\
&\approx \frac{\mu_0}{4\pi}\left[\frac{1}{r^2}\{M_z P_1 + M_x\cos\phi P_1^1 + M_y\sin\phi P_1^1\}\right. \\
&\qquad +\frac{1}{r^3}\{(-M_x x_0 - M_y y_0 + 2M_z z_0)P_2 \\
&\qquad +\sqrt{3}(M_z x_0 + M_x z_0)\cos\phi P_2^1 \\
&\qquad +\sqrt{3}(M_z y_0 + M_y z_0)\sin\phi P_2^1 \\
&\qquad +\sqrt{3}(M_x x_0 - M_y y_0)\cos 2\phi P_2^2 \\
&\qquad \left.+\sqrt{3}(M_y x_0 - M_x y_0)\sin 2\phi P_2^2\}\right],
\end{aligned}$$

where P_ℓ^m is a Schmidt spherical function of degree ℓ and order m. Ψ can also be written as

$$\Psi(r,\theta,\phi) = a\sum_{\ell=1}^{2}\sum_{m=0}^{\ell}\left(\frac{a}{r}\right)^{\ell+1}\left(g_\ell^m \cos m\phi + h_\ell^m \sin m\phi\right) P_\ell^m(\cos\theta),$$

where a is any unit length (for the geomagnetic potential, a is the Earth's mean radius), and

$$M_x = \left(\frac{\mu_0}{4\pi}\right)^{-1} a^3 g_1^1, \quad M_y = \left(\frac{\mu_0}{4\pi}\right)^{-1} a^3 h_1^1, \quad M_z = \left(\frac{\mu_0}{4\pi}\right)^{-1} a^3 g_1^0.$$

Then we obtain the following equation,

$$\begin{pmatrix} -g_1^1 & -h_1^1 & 2g_1^0 \\ \sqrt{3}g_1^0 & 0 & \sqrt{3}g_1^1 \\ 0 & \sqrt{3}g_1^0 & \sqrt{3}h_1^1 \\ \sqrt{3}g_1^1 & -\sqrt{3}h_1^1 & 0 \\ \sqrt{3}h_1^1 & \sqrt{3}g_1^1 & 0 \end{pmatrix} \begin{pmatrix} x_0 \\ y_0 \\ z_0 \end{pmatrix} = a \begin{pmatrix} g_2^0 \\ g_2^1 \\ h_2^1 \\ g_2^2 \\ h_2^2 \end{pmatrix}.$$

Hence, the position of $\boldsymbol{M}$ is given as

$$x_0 = \frac{a(L_1 - g_1^1 E)}{3H^2}, \quad y_0 = \frac{a(L_2 - h_1^1 E)}{3H^2}, \quad z_0 = \frac{a(L_0 - g_1^0 E)}{3H^2},$$

where

$$\begin{aligned} H^2 &= (g_1^0)^2 + (g_1^1)^2 + (h_1^1)^2, \\ L_1 &= -g_1^1 g_2^0 + \sqrt{3}(g_1^0 g_2^1 + g_1^1 g_2^2 + h_1^1 h_2^2), \\ L_2 &= -h_1^1 g_2^0 + \sqrt{3}(g_1^0 h_2^1 - h_1^1 g_2^2 + g_1^1 h_2^2), \\ L_0 &= 2g_1^0 g_2^0 + \sqrt{3}(g_1^1 g_2^1 + h_1^1 h_2^1), \\ E &= \frac{L_0 g_1^0 + L_1 g_1^1 + L_2 h_1^1}{4H^2}. \end{aligned}$$

Lines 125–126

"It ⋯ are centered ⋯" would be "It ⋯ is centered ⋯."

"⋯ a 40 × 40 cm cubic ⋯" would be "⋯ a 40 × 40 × 40 cm cubic ⋯."

Lines 144–147

The authors describe that there is a vertical alignment error as one of errors. This can be reduced if the position of a magnetic dipole moment is simultaneously determined as mentioned above.

Figure 6

The red and black cables are likely to be used as power lines. Are they twisted? If it is not the case, such a configuration may cause additional magnetic field, so that they should be twisted. If it is the case, it is better to point out the configuration.

Equation (6)

The subscript k should be clearly defined. If k stands for x, y or z, the left-hand-side of Equation (6) should be m_k, where $m = (m_x^2 + m_y^2 + m_z^2)^{1/2}$.