Precise measurement of the magnetic field vector with moving carriers

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The use of flux-gate magnetometers onboard mobile carriers faces a number of difficulties that limit their implementation in the practice of geophysical research. This is due to the fact that the measurements of rather weak magnetic anomalies are executed in the presence of strong Earth's magnetic field which creates great interference unavoidably arising when the vector magnetometer rotates during its movement. The analysis of this factor is made and the way to eliminate such errors is discussed.

The geophysical research of Earth's crust structure requires measurements of the Earth's magnetic field vector variations at big areas. Normally, this is made with flux-gate magnetometers (FGMs) in numerous stationary positions to cover all the area. To decrease time and money expenses, recently the attempts are known to do this with the help of moving carriers. In spite that the existing FGM parameters allow their using for magnetic survey with moving platforms, this faces a number of difficulties that limit their implementation in the practice of geophysical research. This is due to the fact that FGM produces three component measurements results in the presence of strong Earth's magnetic field $\mathbf{B}_0$ (the absolute value $|\mathbf{B}_0|$ can reach 67 000 nT), and when the FGM rotates during its movement, great interference is unavoidably arising. To this, EM interference and vibration from the copter motor is the important factor which limits the magnetometer sensitivity level in wide frequency band. The last problem can be solved by proper interference filtration and use of elastic construction design of suspended (towed) FGM. One may believe that the calculation of the magnetic field module after the measured components may allow overcoming the first problem, at least making FGM use competitive to scalar magnetometers. But detailed study showed that even small deflections α_{ij} of FGM sensors from mutual orthogonality (≤0.1 degrees) and non-identities k_i of transfer function of measuring channels (≤0.1%) can lead to "pseudo" anomalies appearance in module values at sensors rotation what is the essential factor which limits the FGM application in practice. The module B calculations results are illustrated below, where the appearing changes are given for dB, dB/d and dB/dθ at B=50000 nT and simultaneous deviations of angles from orthogonality α_{12}=89.9°, α_{23}= α_{13}=90.1° and transfer functions non-identity values k_1=1, k_2=1-5·10^{-4}, k_3=1-10^{-3}. This may create errors up to dB=80 nT, dB/dφ=2 nT/deg and dB/dθ=2.5 nT/deg (see Figure).

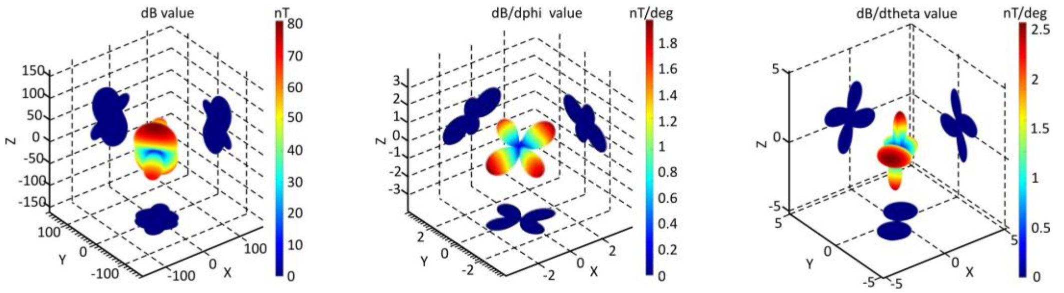

Figure: The possible dB, dB/dφ and dB/dθ errors at B=50000 nT and simultaneous deviations α_{12}=89.9°, α_{23}= α_{13}=90.1°, k_1=1, k_2=1-5·10^{-4}, k_3=1-10^{-3}.

Basing on our calculations, we may estimate the requirements to the sensors non-uniformity errors in order dB(φ, θ) parameter values would be at the level of natural interference - by conservative estimation, do not exceeding 1 nT. Thus, required error should be decreased up to 10^{-3} of angular degree and the control of the magnetic channels transformation coefficient should be at the level 2·10^{-5}, i. e. 0.002%. These conditions require a new approach to FGM application in the dynamic measurements of small anomalies in the Earth's magnetic field. Possible solution is to develop the method to determine the real FGM channels mutual orthogonality deflection and transformation factors non-identity with given precision and to introduce corresponding corrections at data processing. This method is under development now.

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