

A noise suppression method for superconducting full tensor aeromagnetic gradient measurement data

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Aeromagnetic gradient direct measurement with high accuracy becomes possible with the rapid development of a superconducting quantum interference device (SQUID). The superconducting full tensor magnetic gradiometer provides a large amount of information, and high magnetic field sensitivity and other characteristics is the future direction of the new generation of airborne magnetic detection. Sensors also brought greater precision to noise suppression. How to effectively suppress aero-geophysical noise is a key technical problem. In addition to the hardware device by the method of jamming, most conventional soft compensation methods only consider the impact of traditional sources of interference measurements, but often a more complex system of noise in actual flight measurement process, only by means of a single model and associated all kinds of complex processes is difficult to adequately filter out interference. We propose a gradient magnetic data processing method of compensating a more systematic compensation to improve the effectiveness of the actual measurement data.

This paper presents a full tensor gradient aeromagnetic data processing superconducting method. The method can effectively eliminate the use of a multi-source noise measuring platform involved. It includes a sensor internal interference, external interference measurement platform, the induced magnetic field interference, interference measurement system error etc. to improve the data accuracy of the compensation magnetic field gradient, and the entire compensation method of systematic processing process also guarantees the actual data compensation processing efficiency and ease of use.

In view of the limitations of the flight measurement equipment in practice, the data sampling rate of GPS and INS is inconsistent with the sample rate of the magnetometer and magnetic gradient meter, so the resolution of reference magnetic field data resulting from the corresponding calculation is lower than the resolution of the magnetic sensor measurement signal. Under these conditions interpolation precision is allowed, and the data are encrypted using three-time spline interpolation, the magnetic intensity meter and the magnetic gradient data are sampled at some time, so that the original two data sets with different sampling rates are processed to obtain the same length of data samples.

Due to the limitation of the manufacturing process of superconducting chips, the two coils of the plane gradiometer are inconsistent, and each gradient meter contains parasitic three component magnetic field signals. Although the geometric construction of a multi-gradiometer module can reduce its inherent imbalance, the accuracy still cannot meet the actual measurement needs under the geomagnetic background field conditions. It is necessary to install a three axis magnetometer in the gradiometer, and simultaneously measure the magnetic field three components for the measurement of magnetic staircase field data balance compensation processing. Since the measurement environment of the three axis magnetometer is the same as that of the magnetic gradiometer, it will also be affected by a variety of interference noises. Before the compensation of a magnetic gradiometer, the magnetic field data collected by itself must be corrected and compensated. The processing is based on three component data correction and a compensation integrated model of the magnetic field in the coordinate system of the flight measurement platform. Considering the low frequency noise interference of the magnetic sensor, it mainly comes from two parts: internal noise (multiple sensor sensitivity difference, sensor bias, installation error and soft magnetic interference) and external interference (measurement platform remanence magnetic induction, eddy current magnetic interference), combined with three axis magnetometer correction model and Tolles-Lawson. The magnetic compensation model can be set up as a

three component magnetic field data correction compensation integrated model. The correction equation of compensation coefficient can be solved by regularized least square fitting or Huber norm fitting. The accuracy of the solution is determined by the condition number of the coefficient matrix.

In this paper, linear filtering is used to optimize the math model. Selecting the base signal will first estimate the base signal of the current point by using the proximal point information, and then use the estimator as the base vector to reconstruct the interference field linearly. Because the gradient value of the measurement area is very small, the constrained linear least squares data fitting method is used to solve the compensation coefficient. The algorithm can use Trust region reflective (reflective), active set algorithm (Active) or Interior (point). For the existence of local large gradient values in the measurement area, in order to ensure the stability of the solution, the Huber data fitting method is used to solve the compensation co-efficient, and the alternating direction multiplier method (ADMM) is adopted to solve the algorithm. According to the frequency band characteristics of the practical application problem and the background noise frequency band characteristics of the known sensor chip, the low-pass filtering of the compensated data is further processed to improve the accuracy of the compensation data. The low-pass filtering method is used to obtain the final result of magnetic gradient data processing using the Butterworth low pass filter. After compensation and filtering, the mean square root of the magnetic gradient data is less than 20pT and the improvement ratio is IR to 2.3e3.