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重力卫星精密星间测距系统滤波器技术指标论证

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Demonstration on the design of filter indexes of inter-satellite high accuracy ranging system for gravity satellite

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摘要 本文基于重力卫星精密星间测距测量模式,从星间测距观测值与地球重力场频谱关系的角度,建立了距离观测值关于重力位系数的敏感矩阵,分析了各阶次重力场位系数对应的敏感矩阵的频谱特性,讨论了星间测距信息中能反应地球重力场信息的有效信号频带,给出了能最大限度保留地球重力场信息的低通滤波器的通带截止频率、通带增益波纹和频率采样率技术指标设计方案,可为我国首期卫星跟踪卫星重力测量计划的主要技术指标的初步设计提供参考.

关键词 重力卫星, 精密星间测距系统, 滤波器指标设计, GRACE, KBR

Abstract: In order to value the sensitivity of inter-satellite ranging measurements related to gravity field for the satellite-to-satellite tracking model, sensitivity matrix analysis, which is a method of estimating the influence of input parameters on the system model, is applied in this paper. For the inter-satellite high accuracy ranging measurements of gravity satellite, we describe the theory of spectrum analysis of sensitivity matrix for inter-satellite ranging measurements, calculate main sensitivity matrix based on the Kepler satellite orbit for GRACE, analyze the spectrum characteristic of sensitivity matrix for different degree coefficients of gravity field, and explain our results in view of the character of Legendre functions and spherical harmonic functions. In addition, in order to prove the conclusion on spectrum characteristic we simulate several main sensitivity factors for inter-satellite ranging measurements based on gravity field of independent *n* degree *m* order spherical harmonic functions and find good agreement between our simulated models and theory models. Considering the effects of conservative force, non-conservative force and inter-satellite measurement noise, we discuss the effective frequency band of inter-satellite ranging measurements in which the gravity field signal is contained, and get the conclusion that for *n* degree gravity field the upper limit of effective frequency band is due to the spectrum of sensitivity matrix of *n* degree zonal spherical harmonics. Based on the results of gravity signal band, we demonstrate the design of low-pass filter indexes, such as cut frequency of pass-band, gain ripple specifications of pass-band and frequency sample rate, and show the design for current GRACE mission, future GRACE Follow-on mission and our national gravity satellite mission in details. Our results are based on the spectral relationship between sensitivity matrix for inter-satellite ranging measurements and gravity potential, improving the previous methods which are mainly based on the high-frequency noise of inter-satellite ranging measure meters. The results of this paper are able to be applied in the design of the major technique indexes for our future gravity satellite mission.

Keywords Gravity satellite, Inter-satellite high accuracy ranging system, The design of filter indexes, GRACE, KBR

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