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RAI-g量子重力仪野外测试结果分析

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摘　要：量子重力测量是一种新型的观测技术，具有精度高、连续观测和无格值与漂移误差等特点，展现了在大地测量领域的巨大应用潜力。为评估量子重力仪在野外观测环境下的性能，采用RAI-g量子重力仪在武汉所、九峰和襄樊3个野外重力观测站的观测数据，处理得到重力值及其精度信息，并与FG5X绝对重力仪测量结果进行比较。测试结果表明：(1)RAI-g量子重力仪在市区和郊区不同噪声环境下均能实现正常连续绝对重力测量，观测过程中数据噪声类型以白噪声为主，重力值的观测精度优于2 μGal，准确度优于10 μGal；(2)RAI-g重力仪的灵敏度与重力观测站的背景噪声有关，采用位于市区武汉所站的观测数据计算的灵敏度为357 $\mu Gal/Hz^{1/2}$，郊区的九峰和襄樊两个站则分别是72 $\mu Gal/Hz^{1/2}$和89 $\mu Gal/Hz^{1/2}$。RAI-g量子重力仪在3个重力站均取得了优异的观测结果，但其长期稳定性仍需要更多的测试验证。

关键词：量子重力仪；绝对重力；精度；准确度；阿伦偏差

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Analysis of Field Test Results for the RAI-g Quantum Gravimeter

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Abstract：Objectives：Quantum gravimeters are an emerging gravity measurement technology with the potential to significantly change the field of gravity observation. These instruments are based on matter-wave interferometry and use cold atoms as test masses，enabling continuous absolute measurements of gravitational acceleration. Compared with traditional laser-interferometric absolute gravimeters，quantum gravimeters employ atomic matter waves with much shorter wavelengths and avoid mechanical friction by using microscopic atoms as test masses. In comparison with spring-based or superconducting gravimeters，quantum gravimeters combine continuous observation capability with absolute measurement，and are theoretically free from scale factor errors and instrumental drift. These characteristics give quantum gravimeters strong potential for acquiring high-quality gravity data. In recent years，quantum gravimeters have developed rapidly；however，most existing studies and tests have been conducted under laboratory conditions. As a result，

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their performance under field conditions is still not well understood. In addition, key performance indicators reported by instrument manufacturers, such as precision, accuracy, and stability, require independent verification through field experiments. Therefore, field testing of quantum gravimeters is essential for evaluating their practical observation capability, understanding the influence of environmental factors on instrument performance, and promoting their engineering development and practical application. Based on this background, this study focuses on the RAI-g quantum gravimeter and systematically analyzes its precision, accuracy, and stability under different environmental conditions through mobile observations at multiple stations, providing experimental evidence for its application in high-precision gravity measurements. **Methods:** Field performance tests were carried out using the RAI-g quantum gravimeter developed by Huazhong University of Science and Technology. The instrument uses rubidium atoms as test masses and integrates key technologies including atomic matter-wave interferometry, real-time data acquisition and processing, and active vibration isolation. It features high measurement precision and good portability, making it suitable for mobile absolute gravity observations. The tests were conducted in a mobile observation mode in November 2020 at three sites in China: the Absolute Gravity Laboratory of the Institute of Seismology, China Earthquake Administration (Wuhansuo), Jiufeng Seismic Station (Jiufeng), and Xiangfan Seismic Station (Xiangfan). All three sites are equipped with stable gravity pillars, and the gravity reference at each site is maintained through repeated measurements with an FG5X absolute gravimeter, providing reliable reference gravity values. The background vibration environments at the three sites differ significantly. The Wuhansuo site is located in an urban area with frequent human activity and relatively high vibration noise. The Jiufeng station is located inside a cave, with a quiet environment and the lowest vibration level. The Xiangfan station is located in a suburban area, with vibration noise levels between those of Wuhansuo and Jiufeng. In addition, the absolute gravity values at the three sites differ by nearly 60 mGal, and the latitude and elevation conditions also vary, providing favorable conditions for a comprehensive performance evaluation of the instrument. The RAI-g quantum gravimeter completes one gravity measurement every 6 s and supports continuous observation. The observation duration at each site ranged from 3 to 15.2 h. All instrument operations during the tests were performed by manufacturer technicians, and the operators were unaware of the prior gravity values at the sites. After data processing, the RAI-g results were compared with the colocated FG5X absolute gravimeter measurements to evaluate the field performance of the instrument. **Results:** The observation results show that the data distributions obtained by the RAI-g quantum gravimeter differ among the three sites. The data at the Jiufeng station are the most concentrated, followed by Xiangfan, while the Wuhansuo site shows the largest dispersion. This pattern is consistent with the background vibration noise levels at the sites, indicating that ground vibration is a major factor affecting the measurement quality of quantum gravimeters. During absolute gravity measurements, ground vibrations introduce errors by changing the relative position between the Raman reflection mirror and the freely falling atoms. The RAI-g quantum gravimeter uses an accelerometer to monitor vibrations in real time and applies vibration compensation, enabling stable continuous observations. Nevertheless, data quality is higher in low-noise environments. Using the FG5X absolute gravimeter measurements as reference values, a quantitative evaluation of the RAI-g results was performed. The observation precision of the RAI-g at all three sites is better than 2 μGal. In particular, the precision at Jiufeng and Xiangfan reaches 0.29 μGal and 0.44 μGal, respectively, achieving the microgal level. In terms of accuracy, defined as the difference between the mean observed value and the reference value, the results at Wuhansuo, Jiufeng, and Xiangfan are 1.70 μGal, −2.06 μGal, and 7.35 μGal, respectively, all better than 10 μGal. These results indicate that systematic errors of the instrument are well controlled. Outliers and random error distributions were further analyzed. Individual measurements differing from the mean of the observation series by more than three times the standard deviation were identified as containing outliers. The proportions of outlier observations at Wuhansuo, Jiufeng, and Xiangfan are 18‰, 8‰, and 4‰, respectively, all less than 2% and comparable to those of the FG5X absolute gravimeter. This demonstrates that the RAI-g has good resistance to outliers. After removing outliers, the error histograms of the remaining data at all sites show approximately symmetric distributions with sums close to zero, consistent with the statistical characteristics of random errors and without evident systematic bias. Instrument stability was evaluated by calculating the Allan deviation of the continuous observation data. The sensitivities of the RAI-g at the Wuhansuo, the Jiufeng, and the Xiangfan are 357 μGal/Hz$^{1/2}$, 72 μGal/Hz$^{1/2}$, and 89 μGal/Hz$^{1/2}$, respectively. The differences in sensitivity are mainly influenced by background vibration conditions. Quieter environments result in lower data dispersion and higher instrument sensitivity. At all sites, the Allan deviation curves continuously decrease with increasing integration time, indicating that white noise is the dominant noise type. No obvious colored noise was observed during the measurements, demonstrating good short-term stability of the instrument. In addition, the tests show that the instrument accuracy changed only slightly after short-distance transportation (from the Wuhansuo to the Jiufeng), while a larger but still acceptable change was observed after long-distance transportation (from the Jiufeng to the Xiangfan). Even after long-distance transport, the accuracy remained better than 10 μGal, indicating that transportation may affect the instrument state to some extent, but the overall performance remains stable. **Conclusions:** In conclusion, the RAI-g quantum gravimeter is capable of stable and continuous absolute gravity measurements under different environmental conditions. It achieves microgal-level precision, accuracy better than 10 μGal, good stability, and strong resistance to outliers. Background vibration noise at observation sites is the main factor affecting instrument sensitivity and data dispersion. However, with effective vibration monitoring and compensation, the instrument can maintain high data quality under field conditions. The RAI-g quantum gravimeter shows strong potential for applications in geodesy and geophysics. Future studies should include longer-term observations and tests under more complex environmental conditions to further evaluate its long-term stability and engineering adaptability, thereby supporting the broader application and further development of quantum gravimeters.

Key words: quantum gravimeter; absolute gravity; precision; correctness; Allan deviation

新的测量技术可能会带来测量领域的颠覆性变革。量子重力仪,又称冷原子重力仪,是一种新型重力观测仪器。该仪器采用物质波干涉原理进行重力值测量,既能实现绝对重力值测量,又能进行连续重力测量。相比较于传统的激光干涉型绝对重力仪,量子重力仪采用 的原子物质波波长短于光波,且其是采用微观原子作为检测质量,无机械摩擦。相比于弹簧型连续重力仪和超导重力仪,量子重力仪能连续实现绝对重力值观测,理论上没有格值和漂移误差。这些特点有利于量子重力仪获取高质量重力观测数据。

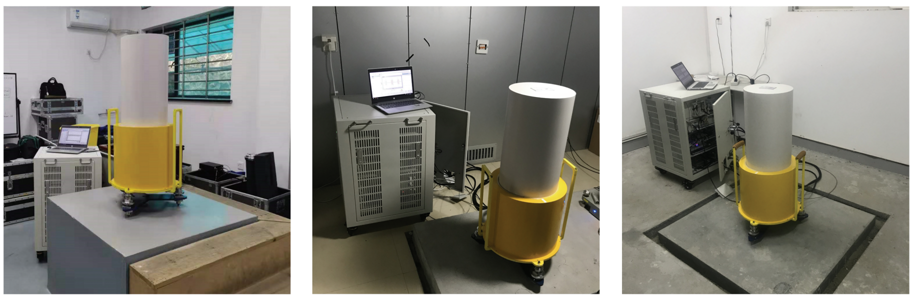
1991年,斯坦福大学朱棣文课题组利用钠原子干涉仪实现了绝对重力测量[1]。随后,量子重力观测技术备受关注,并取得了巨大发展,目前高精度量子重力仪的灵敏度已达到4.2 μGal/Hz$^{1/2}$[2]。国际上,法国Muquans公司最早研发了商品化的AQG型量子重力仪,其结构紧凑,便于运输,能自动完成连续数据采集,观测精度达到数微伽量级,安静观测环境下仪器灵敏度达到50 μGal/Hz$^{1/2}$[3]。近些年,国内量子重力仪同样发展迅速。中国科学院精密测量科学与技术创新研究院、华中科技大学、浙江大学、浙江工业大学、中国计量院和中国科学技术大学等单位已经成功研制了高精度的量子重力仪[2,4-8]。2017年第10届国际绝对重力仪比对观测期间,国内部分量子重力仪研发单位携带他们的仪器参加了比对观测,比对结果显示国内仪器性能与国际水平相当[9]。尽管目前量子重力仪发展迅速,但该类型仪器绝大多数测试是在实验室条件下完成,导致对于量子重力仪在野外条件下的观测数据质量了解不充分。此外,量子重力仪研制厂家公布的精度等参数需要检验和确认。因此,十分必要开展量子重力仪的野外测试并分析仪器的性能指标,以便认识和评估量子重力仪的野外性能,推进仪器迭代升级更新和在大地测量与地球物理等领域应用。

RAI-g型重力仪(图1)是一款由华中科技大学研制的高精度、可搬运的量子重力仪,其采用铷原子作为测试质量,能实现原子物质波干涉和

实时数据采集处理,同时具有隔振设备。本文采用RAI-g型量子重力仪,在3个重力观测站开展野外流动绝对重力测试,对观测数据进行处理并与同址FG5X绝对重力仪观测值进行比较,分析仪器观测重力值的精度、准确度和阿伦偏差等性能指标,最后展望该仪器在大地测量领域的应用前景。

1 RAI-g量子重力仪测试

精密绝对重力测量通常需要在稳定的观测墩上开展。RAI-g量子重力仪测试选择的观测场地(图1)分别为中国地震局地震研究所的绝对重力实验室的重力观测墩(武汉所)、九峰地震台的重力观测墩(九峰)和襄樊地震台的重力观测墩(襄樊)。3个重力观测站是中国地震重力监测网络的基准站,均拥有稳定的观测墩,且采用FG5X绝对重力仪进行重复观测以维持重力基准[10]。3个站背景噪声存在差别,其中武汉所站位于市区,而九峰站和襄樊站则位于郊区;3个站中武汉所站和九峰站纬度和高程接近,但它们与襄樊站存在差异,3个站绝对重力最大最小值相差接近60 mGal。三者不仅满足精密绝对重力测量要求也是开展RAI-g量子重力仪测试的理想场所。



(a) 武汉所 (b) 九峰 (c) 襄樊

图1 RAI-g量子重力仪在武汉所、九峰和襄樊观测站

Fig. 1 RAI-g Quantum Gravimeter at the Wuhan Institute, the Jiufeng and the Xiangfan Observation Stations

RAI-g量子重力仪的测试方案是首先在3个重力站采用量子重力仪进行观测,然后将观测结果与目前综合性能最好的FG5X绝对重力仪结果进行对比,评估量子重力仪观测结果精度和准确度等性能指标。测试工作的观测模式采用绝对重力测量的流动观测模式,即将重力仪运输至一个测站进行观测,结束后再运输至另一个重力站直至观测结束。2020年11月,在3个重力站分别开展了量子重力仪测试。测试顺序为由武汉所站至九峰站,最后在襄樊站结束。测试过程中所有关于RAI-g量子重力仪的操作均由厂家技术人员完成。为实现盲测,所有测试流程中仪器操作人员均不知道观测站的先验重力值。

RAI-g量子重力仪配备有测重力软件,该软件具有重力测量时序控制、气压等外部环境数据提取、重力数据处理和输出等功能。量子重力仪每6 s能完成一次重力加速度测量,且具备连续观测能力。本文利用测重力软件对观测数据进行采集和处理,获得了3个重力站的原始重力观测结果,每个站所有重力观测值均减去了常数,如图2所示,其中蓝点表示量子重力仪每次绝对重力测量值(均减去了常数),绿线表示Eterna软件计算的固体潮信号。RAI-g量子重力仪在3个重力站能实现连续绝对重力测量。各重力站观测时间从3 h至15.2 h不等,但所有站点的观测结果均能清晰显示重力固体潮信号。

2 测试结果分析

RAI-g量子重力仪在3个重力站的原始观测结果如图2所示,经潮汐、气压变化和极移等效应改正后得到修正后的观测值,所有结果均已减去了常数,如图3所示。由图3可以看出,3个重力站观测结果分布的密集程度存在差异,九峰站重力观测值分布最为密集,襄樊站次之,武汉所站最离散。这种分布差异与重力站背景振动噪声有关。武汉所站位于武汉市区,站点周边车辆和人员活动频繁,背景噪声大。襄樊站尽管位于襄阳市郊区,但站点附近车辆和人员活动较为频繁。而九峰站位于山洞内部,站点周围500 m范围内没有显著的人为活动,属于安静的观测站。

用于精密绝对重力测量的重力仪需要有较好的地面振动误差抑制性能。固定在地表的重力仪进行绝对重力测量过程中,地面振动会导致重力仪处于非惯性系中,且重力仪测量的重力加速度和地面振动加速度无法区分,这会导致观测

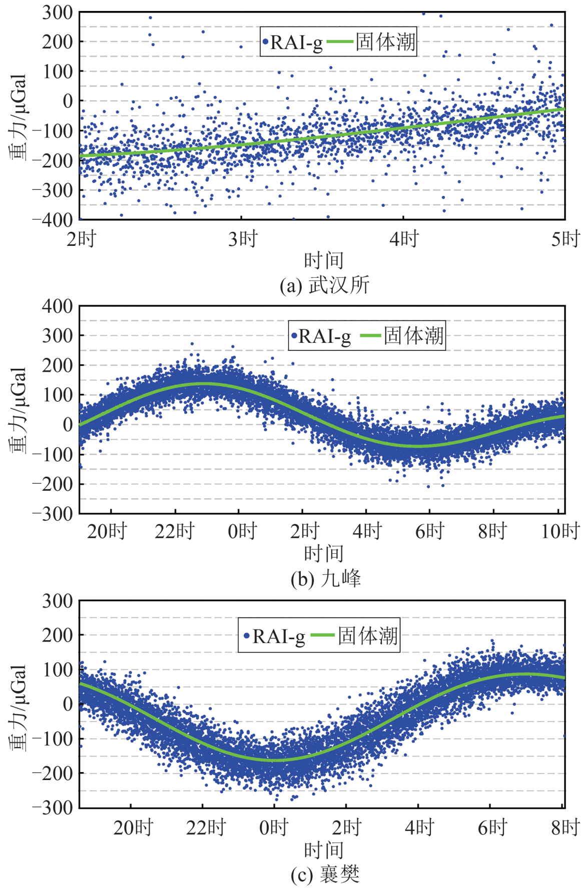


图 2　RAI-g量子重力仪原始观测结果

Fig. 2　Raw Observational Results of RAI-g Quantum Gravimeter

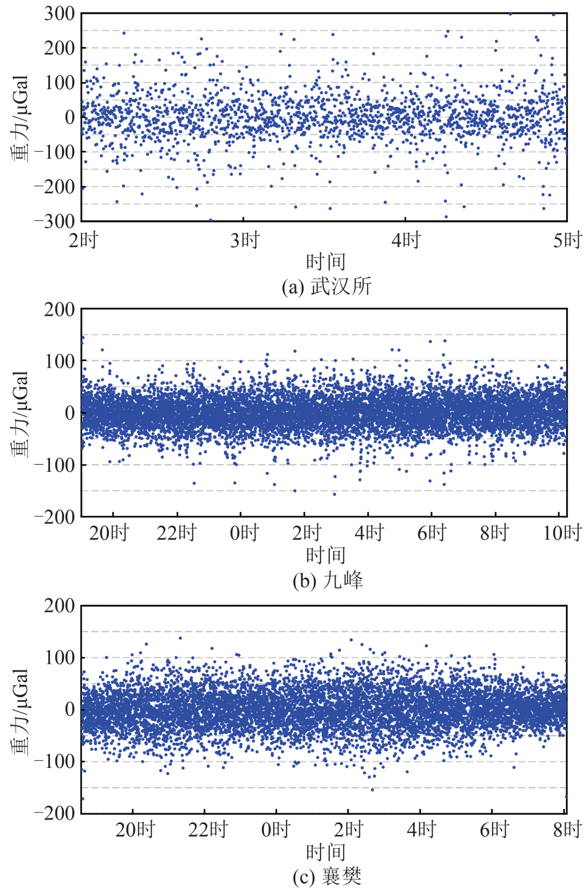


图 3　RAI-g量子重力仪改正后的观测结果

Fig. 3　Corrected Observational Results of RAI-g Quantum Gravimeter

结果引入地面振动误差。基于物质波干涉原理的量子重力仪测量绝对重力时,地面振动会引起拉曼光反射镜的波动,改变激光和自由下落原子的相对位置,从而将地面振动误差传入观测结果。RAI-g量子重力仪采用加速计监测地面振动,并据此对重力观测值进行补偿,以抑制地面振动误差。图3显示的结果表明,无论是市区背景噪声较大观测站还是郊区安静观测站,RAI-g量子重力仪均能实现正常连续绝对重力测量,但观测环境安静的台站测量结果分布更加密集。

为评估RAI-g-001量子重力仪观测值与3个重力站参考重力值之间的差异,本文搜集了各站点使用其他类型成熟绝对重力仪所获得的观测结果。这3个重力站通常采用FG5、FG5X和A10 3款绝对重力仪进行重复绝对重力测量。其中,A10的观测精度较FG5X低一个量级;而FG5X作为FG5的升级型号,其观测结果具有更小的离散度和更高精度,是目前综合性能最好、应用最广泛的绝对重力仪[9, 11-13]。因此,本文选择各重力站的FG5X绝对重力仪测量值作为站点重力参考值。武汉所站的FG5X观测数据是在RAI-g重力仪观测结束后立即采集完成,而九峰站和襄樊站的数据分别采集于2019年9月和2019年6月。图4展示了FG5X绝对重力仪在3个重力观测站每次下落重力值分布。这些数据已经进行了潮汐、气压变化和极移改正,并采用实测重力垂直梯度归算至RAI-g量子重力仪的绝对重力值测量的高度。此外,所有结果均减去了常数。

由于九峰站和襄樊站FG5X绝对重力仪与RAI-g量子重力仪观测时间存在十多月间隔,在比较两种仪器观测结果时,需考虑陆地水储量变化所引起的重力变化[14]。因此,本文基于全球陆面数据同化系统(global land data assimilation system,GLDAS)/NOAH模型数据(土壤湿度和雪深),采用负荷理论计算了2019年6月至2020年11月上述两站因水文环境变化导致的重力变化(图5),其中紫线和洋红线分别表示九峰站和襄樊站的重力变化。由图5可知,两个站水文环境变化引起的重力变化幅度较小,最大与最小值之差小于3 μGal。从FG5X绝对重力仪观测至RAI-g量子重力仪观测间隔的时间内,九峰站和

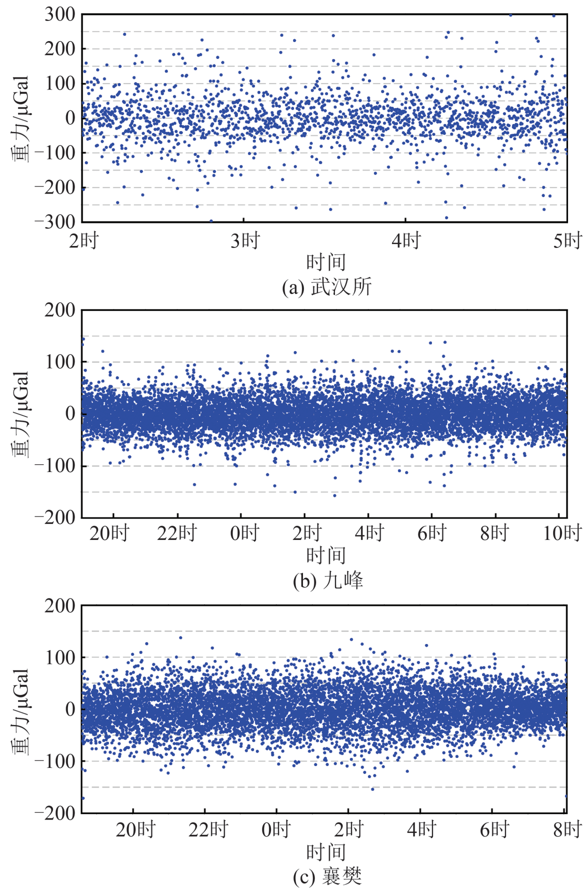


图4 FG5X绝对重力仪观测结果

Fig. 4 Observational Results of FG5X Absolute Gravimeter

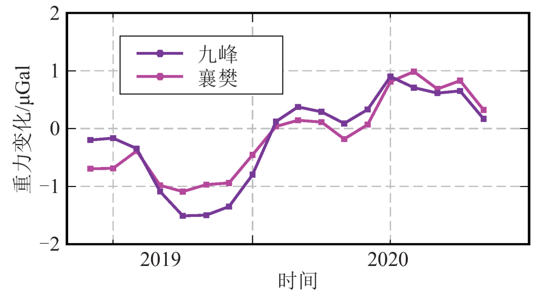


图5 采用GLDAS/NOAH水文模型计算的九峰站和襄樊站重力变化

Fig. 5 Gravity Changes Calculated from the GLDAS/NOAH hydrological model at the Jiufeng Station and the Xiangfan Station

襄樊站重力变化分别为1.26 μGal和1.02 μGal。

RAI-g量子重力仪和FG5X绝对重力仪在3个重力站观测结果见表1,表1中的两种类型重力仪观测结果均进行了相关处理。其中量子重力仪结果是首先从图3展示的观测数据中剔除超过3倍观测数据序列标准差的数据(表1中拒绝观测数),然后将剩余数据(表1中接收观测数)的平均值及其中误差作为重力仪观测的测站重力值及其精度。FG5X重力仪观测数据采用g9软件处理,策略与量子重力仪类似。FG5X重力仪观测数据处理得到的重力值加上图5中水文引起的重力变化即为量子重力仪观测时重力站重力值的参考值,表1中两种类型重力值结果均减去了每个重力站重力值的参考值。

由表1可知,RAI-g量子重力仪在3个重力站观测的重力值精度均优于2 μGal,特别是在九峰站和襄樊站精度分别达到了0.29 μGal和0.44 μGal。量子重力仪观测得到的重力值精度与仪器每次观测数据总体分布的密集程度和总观测数有关。图3显示的3个重力站中,量子重力仪观测结果分布均较为密集,且均实现了数千次正常绝对重力测量。RAI-g量子重力仪精度测试结果表明该仪器的观测精度达到了数微伽量级。

表1 RAI-g量子重力仪和FG5X绝对重力仪观测结果

Table1 Observational Results of RAI-g Quantum Gravimeter and FG5X Absolute Gravimeters

观测站	时间	仪器	重力/μGal	接收观测数	拒绝观测数
武汉所	2020-11-17	RAI-g-001	−1.70±1.83	1 767	33
	2020-11-20—2020-11-22	FG5X-259	0±0.95	3 784	16
九峰	2020-11-27—2020-11-28	RAI-g-001	2.06±0.29	9 067	70
	2019-09-19—2019-09-21	FG5X-259	0±0.18	8 973	27
襄樊	2020-11-29—2020-11-30	RAI-g-001	−7.35±0.44	8 054	33
	2019-06-06—2019-06-07	FG5X-246	0±0.18	2 451	49

本文中采用准确度来评估量子重力仪的系统误差。量子重力仪准确度定义为重力站绝对重力参考值与重力仪观测绝对重力值之差。由表1可得量子重力仪在武汉所站、九峰站和襄樊站测试结果的准确度分别为1.70 μGal、−2.06 μGal和7.35 μGal。上述结果表明RAI-g量子重力仪准确度优于10 μGal。

3 讨 论

RAI-g量子重力仪观测结果中粗差和偶然误差分布是评估仪器性能的重要依据。本文将每

次观测结果与平均值之差超过3倍观测数据序列标准差的观测视作含有粗差的结果。由表1可知,RAI-g重力仪在武汉所站、九峰站和襄樊站包含粗差观测数占总观测数之比分别为18‰、8‰和4‰,3个重力站FG5X重力仪结果分别为4‰、3‰和19.6‰。RAI-g重力仪包含粗差的观测结果占比均小于2%,且与FG5X绝对重力仪观测结果中粗差比例相当,这些优异表现说明该仪器具有较好抵抗粗差的能力。假设RAI-g量子重力仪在3个重力站观测数据剔除粗差后,剩余数据不存在系统误差。

图6为根据剩余观测数据绘制的观测数据误差分布直方图,其中横轴表示每次观测数据误差(每次观测数据与平均值之差),纵轴为对应区间观测数据数量。由图6可以看出,量子重力仪武汉所站误差绝对值均小于400 μGal,九峰站和襄樊站则分别小于100 μGal和120 μGal;3个重力站误差绝对值较小观测数据数量大于误差绝对值大的观测数据;3个重力站正负误差分布大致对称;武汉所站、九峰站和襄樊站所有观测数据误差之和分别为1.1 μGal、0.13 μGal和−0.03 μGal,与误差正负变化范围相比误差之和基本接近0。上述结果表明RAI-g量子重力仪在3个重力站观测数据误差分布基本满足偶然误差统计特性。

RAI-g量子重力仪的一大优势是能够连续进行绝对重力测量。重力仪连续观测数据的稳定性是影响观测结果质量的重要依据。为分析量子重力仪观测过程中的稳定性,本文计算了3个重力站观测数据的阿伦偏差(图7)。采用图7中阿伦偏差结果拟合了RAI-g量子重力仪在武汉所、九峰和襄樊站观测结果的灵敏度分别为357 μGal/Hz$^{1/2}$、72 μGal/Hz$^{1/2}$和89 μGal/Hz$^{1/2}$,即3个重力站观测精度要达到1 μGal所需要的观测时间分别为35.40 h、1.44 h和2.20 h。RAI-g量子重力仪的灵敏度在3个重力站不一致,结合图3观测结果分布和图6误差分布直方图可知,重力仪灵敏度与观测站背景环境振动有关,观测站测量结果离散度越大对应的灵敏度越低。由图7中阿伦偏差曲线可知,3个站阿伦偏差随时间增加而不断减小,这说明RAI-g量子重力仪重力观测过程中白噪声为主要噪声类型。尽管RAI-g量子重力仪在背景噪声不一样的台站灵敏度存在差别,但所有3个重力站连续观测数据不存在显著有色噪声,仪器测量过程中具有较好稳定性。

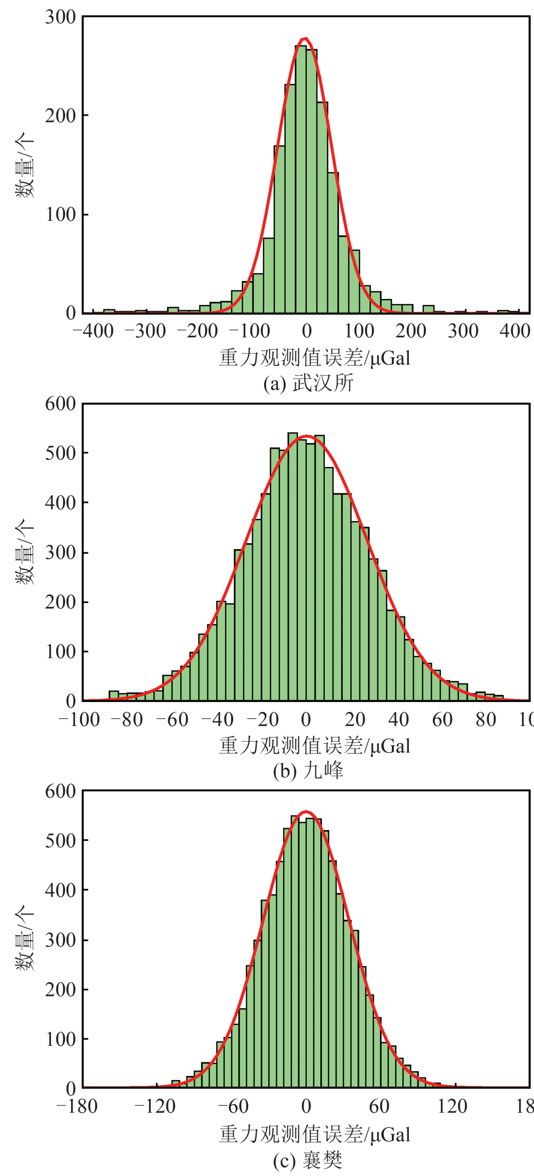


图6　RAI-g量子重力仪观测数据误差分布直方图

Fig. 6　Histogram of Observational Data Errors for RAI-g Quantum Gravimeter

RAI-g量子重力仪观测结果中含有的系统误差是决定仪器性能的重要因素。本文中采用FG5X绝对重力仪观测结果作为参考值,将量子重力仪观测结果与其比较得到准确度来衡量量子重力仪系统误差大小。多次国际绝对重力仪比对观测结果和陆态网络绝对重力基准观测结果均表明,FG5X绝对重力仪之间不存在显著系统性偏差[9,11-12,15-16]。国内绝对重力仪比对观测结果显示,本文中使用FG5X-246和FG5X-259两台绝对重力仪与其它编号FG5X绝对重力仪比对观测重力值之差绝对值不超过4 μGal[17-18]。因此,采用本文中FG5X-246和FG5X-259两台绝对重力仪在3个重力站观测值作为重力参考值合理。RAI-g量子重力仪台站测试顺序为武汉所站至九

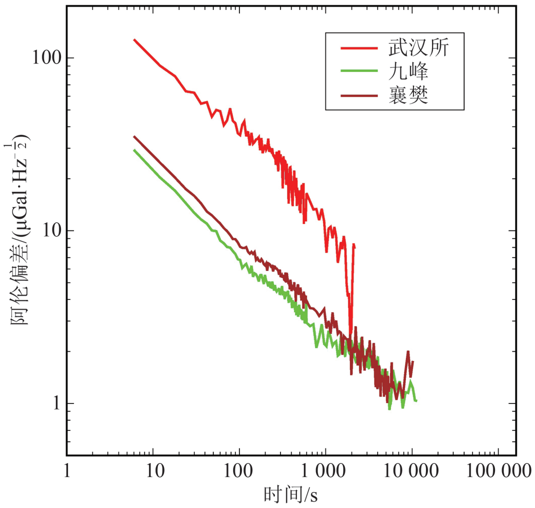


图7 RAI-g量子重力仪观测数据的阿伦偏差

Fig. 7 Allan Deviation of Observational Data for RAI-g Quantum Gravimeter.

峰站，最后为襄樊站。武汉所站至九峰站路程约19 km，而九峰站至襄樊站路程约331 km。尽管武汉所站重力值精度是3个台站最低，但其准确度结果与九峰站相当，且优于襄樊站结果。量子重力仪经过短途运输，其准确度没有显著变化，但经过长距离运输至襄樊站，其准确度指标低于未长距离运输观测结果。本文测试结果表明，量子重力仪经过长距离运输后，其观测结果准确度略微下降，但仍然优于10 μGal。

大地测量对于重力测量精度的要求可以分为毫伽量级和微伽量级两类。本文中RAI-g量子重力仪测试结果显示其观测精度优于2 μGal，能满足大地水准面建立、精密水准测量中重力改正和均衡重力异常等领域毫伽级重力观测精度要求。微伽级重力观测数据常用于地表及内部质量迁移导致的重力变化研究，量子重力仪的精度指标展示了在时变重力领域应用的较大潜力。需要注意的是，时变重力通常需要几年甚至几十年重力观测资料，重力仪本身的稳定性对于观测结果的影响较大。上面对于量子重力仪稳定性分析仅限于仪器观测过程中，在更长时间内仪器的稳定性需要后续长期测试来确定。

4 结 语

本文采用RAI-g量子重力仪，分别在背景噪声不同的武汉所、九峰和襄樊3个重力站开展了流动绝对重力测量，利用观测数据计算了每个重力站重力值及其精度、准确度和阿伦偏差，并将观测结果与每个站FG5X绝对重力测量结果对比分析。测试分析结果表明，RAI-g量子重力仪在3个重力站均能实现正常绝对重力测量，绝对重力测量值的平均值精度均优于2 μGal，准确度均优于10 μGal。3个站阿伦偏差结果表明，量子重力仪观测数据以白噪声为主要噪声类型，观测过程中仪器具有较好稳定性。量子重力仪观测数据在3个站计算的灵敏度存在差异，背景噪声较大的武汉所站灵敏度最差，为357 μGal/Hz$^{1/2}$，位于郊区的九峰和襄樊两个站结果分别约是武汉所站的1/4和1/5，台站背景噪声制约仪器灵敏度。RAI-g量子重力仪能满足毫伽级精度重力观测要求，并且在微伽量级的时变重力应用领域展现了较大潜力。

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