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The Impact of Solar – Terrestrial Plasma and Magnetic Field on the Detection of Gravitational Waves

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Space-borne gravitational waves (GWs) detection raises a new question for heliophysics: how does the solar-terrestrial space environment affect space-borne GWs detection? The space-borne GWs detection will use laser interferometry to measure the changes of displacement between two free test masses caused by GWs. the laser ranging accuracy is required to the order of picometer (10^{-12} m/Hz$^{0.5}$), and the acceleration measurement accuracy, which describes whether the mass is "free", is required to the order of 10^{-15} m/s^2/Hz$^{0.5}$. We find that the space environment can cause two major effects on GWs detection: one is optical path difference (OPD) noise caused by laser propagation in space plasma; the other are magnetic moment force and Lorentz force generated by the interaction of space magnetic field with the test mass. Here, we evaluate the OPD noise due to space plasma, and the acceleration noise due to space magnetic field by magnetohydrodynamic (MHD) simulations and in-situ observations. We find that the acceleration noise due to the space magnetic field is of the order of 10% for the requirement of TianQin GWs detection at 1 mHz. In the range of 1 mHz to 1 Hz, the OPD noise due to laser propagation is maximum at 10 mHz, reaching 30% of the TianQin's requirement. Moreover, we have found that time-delay interferometry can suppress the OPD noise, which can suppress the OPD noise to <10% of the TianQin's requirement.