Dear Editor,

I am pleased to submit our manuscript entitled **"Optimization and Active Stabilization of a Far-Infrared Laser for NSTX-U High Poloidal Wavenumber Scattering Diagnostics"** for consideration for publication in Review of Scientific Instruments.

In this work, we report the development of an optimized far-infrared (FIR) laser system, specifically designed to meet the demanding requirements of high poloidal wavenumber scattering diagnostics on the National Spherical Torus Experiment-Upgrade (NSTX-U). Accurate measurement of electron-scale turbulence in fusion plasmas requires both high beam quality and long-term output power stability.

To address these challenges, we have implemented a precision mirror alignment methodology utilizing a visible HeNe laser reference, which ensures a quasi-Gaussian beam profile well-matched to the transmission line waveguide. Furthermore, we developed and integrated an active feedback control system for real-time cavity length tuning, which compensates for thermal expansion effects and stabilizes the output power at approximately 30 mW. We also investigated and identified optimal formic acid gas pressures to balance maximum output power and operational stability.

The resulting FIR laser system achieves a beam waist of 10.8 mm and maintains stable operation over extended periods, satisfying the requirements of the NSTX-U high-k scattering system. The presented techniques and results offer valuable guidance for other laser-aided diagnostic systems requiring high spatial resolution and robust long-term performance.

We confirm that this manuscript has not been published previously and is not under consideration elsewhere. All authors have approved the manuscript and agree with its submission to Review of Scientific Instruments.

We believe that our findings will be of interest to the readers of RSI, particularly those working in the areas of advanced laser systems, plasma diagnostics, and fusion instrumentation.

Thank you very much for your consideration. We look forward to your feedback.

Sincerely,

Xinhang Xu  
(On behalf of all co-authors)