Dear editor,

We submit our manuscript titled "High-order fluctuations of temperature in hot QCD matter" for consideration as a Letter in *Physical Review Letters*.

Recent new measurements at the RHIC and LHC reveal that event-by-event mean transverse momentum fluctuations of charged particles, closely related to the temperature fluctuations, serve as an ideal probe of QCD thermodynamics. A new thermodynamic state function is introduced to describe the thermodynamics for the relevant heavy-ion collision experiments for the first time, allowing to compute the temperature fluctuations from the basic thermodynamic relations. The temperature fluctuations are suppressed remarkably as the system transitions from the hadron resonance gas (HRG) to the quark-gluon plasma (QGP) with increasing temperature or baryon chemical potential, alongside a negative skewness, in a general and model-independent way. These results provide a unique signature to discover the thermodynamical temperature fluctuations in upcoming heavy-ion collision experiments and offer a novel approach to study the QCD phase diagram.

We believe this research aligns with the high scientific standards of *Physical Review Letters* and would greatly appreciate your consideration.

Sincerely yours,

Jinhui Chen, Wei-jie Fu, Shi Yin, and Chunjian Zhang