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Can two-temperature treatments in GRMHD simulations reduce the predicted variability compared to historical observations of Sgr A*?

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Recent direct imaging by the Event Horizon Telescope Collaboration (EHTC) has confirmed the existence of an event horizon in Sagittarius A*(Sgr A*), the supermassive black hole at the center of the Milky Way. To model and interpret these data, the EHTC compares them to a library of fiducial models based general relativistic magnetohydrodynamic (GRMHD) simulations. One significant source of inaccuracy stems from the fact that the evolution equations model only a single-particle fluid with temperature associated with the proton temperature, and thus do not account for the electrons self-consistently. Instead, as an approximation, the EHTC uses a pre-determined prescription of the temperature ratio between electrons and protons typically based on the local magnetisation of the plasma. This approximation strongly affects the predicted emission, since the radiative transfer depends on the electron temperature assuming a thermal distribution function. One way these models can be tested is via variability of light curves at 230 GHz. Observations of Sgr A* spanning decades give very strong constraints on the variability, and so far all of the strongly magnetized models used by the EHTC show too much variability comparatively. Moreover, none of the models successfully pass all the variability and multiwavelength constraints together.

The temperature ratio between protons and electrons depends on a balance between microphysical dissipation not captured in ideal fluid simulations, radiative cooling, and fluid transport. Therefore, we investigate the effects of two-temperature thermodynamics of a magnetically arrested disk around Sgr A*, *where the temperatures of both species are evolved more self-consistently following a method by Ressler et al. (2015) and Sadowsky el al. (2017). We include Coulomb coupling, heating of non-thermal electrons via an assumed magnetic reconnection mechanism (Rowan et al. 2017) and radiative cooling. Simulations incorporating radiative cooling already show differences in the dynamical and geometrical properties of the accretion flow compared to fiducial models, but the inclusion of heating in addition and two-temperature thermodynamics has not been studied, particularly at higher resolution. These effects also depend strongly on accretion rate which is another unknown variable. In this talk I will present our recent study of the impact of these effects on the predicted light curve and morphology of the accretion flow close to the black hole, and compare our results to the fiducial models used by the EHTC in its 2022 study of the first campaign on Sgr A*.*

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