Contribution ID: **6** Type: **E-Poster Presentation**

Energy outflow efficiency of the supercritical accretion disks around Kerr-black holes by General relativistic radiation-MHD simulations; From weak to strong magnetic field state.

Sunday, 25 June 2023 17:33 (2 minutes)

By performing two-dimensional general relativistic radiation magnetohydrodynamics (GRRMHD) simulations with various spin parameters, a^*, we investigate the supercritical disks in the standard and normal evolution (SANE) and magnetically arrested disk (MAD) states. As a result, it is revealed that the energy outflow efficiency increases with $|a^*|$ in the SANE state. For example, it is 5% for a^*=0.7, which is much larger than 0.3% for a^*=0, when the disk is in the SANE state and the mass accretion rate is $\sim 100 L_{\rm Edd}/c^2$ ($L_{\rm Edd}$ is Eddington luminosity). Such $|a^*|$-dependence appears if the disk is in the MAD state. In addition, we find that energy outflow efficiency is about ten times larger in the MAD state than in the SANE state. That is, the mass accretion rate to explain the energy of luminous compact objects such as AGNs and ULXs is lowest for rapidly rotating black holes with disks in the MAD state and highest for non-rotating black holes with disks in the SANE state. In both cases, although the disk releases the energy mainly by the radiation in the case of the non-rotating black holes, the energy is ejected through the Poynting flux when the black holes rapidly rotate. Therefore, the objects, of which the central black holes rapidly rotate, are identified as powerful sources with a large ratio of kinetic power to photon luminosity. Using this argument, the spin parameter of the black hole of ULX, IC 342 X-1, is expected to be $|a^*| >$0.5.

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Session Classification: Flash Talks