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The photosphere emission spectrum of hybrid relativistic outflow for gamma-ray bursts

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The photospheric emission in the prompt emission is the natural prediction of the original fireball model for gamma-ray burst (GRB) due to the large optical depth ($\tau > 1$) at the base of the outflow, which is supported by the quasi-thermal components found in several Fermi GRBs. However, the main origin of the most prompt emission spectrum (photosphere or synchrotron) is still under hot debate. To explore this problem, the shape of the observed photosphere emission spectrum from a pure hot fireball or a Poynting-flux-dominated outflow has been investigated. In this work, we further study that for the hybrid outflow containing a thermal component and a magnetic component with moderate magnetization ($\sigma_0 = L_P/L_{\rm Th} \sim 2-9$), by invoking the probability photosphere model. It is interesting to find that the high-energy spectrum is a power-law rather than an exponential cutoff, compatible with the observed Band function in large amounts of GRBs. Also, the distribution of the low-energy indices (corresponding to the peak-flux spectra) is found to be quite consistent with the statistical result for the peak-flux spectra of GRBs best-fitted by the Band function, with the similar angular profiles of the dimensionless entropy η as those of the unmagnetized jet considered in our previous works. Finally, the observed distribution of the high-energy indices can be well understood after considering the different magnetic acceleration (due to magnetic reconnection and kink instability) and the angular profiles of η with the narrower core.

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