Very Bright Prompt and Reverse Shock Emission of GRB 140512A

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➢ Summary

We report our observations of very bright prompt optical and reverse shock optical emission of GRB 140512A and analyze its multi-wavelength data by using our data together with data observed with the swift and fermi missions. It is found that the joint optical-X-ray-gamma-ray spectrum with our first optical detection (R=13.09 mag) at T_0 + 136 seconds during the second episode of the prompt gamma-ray may be prompt optical emission. Both empirical and theoreticall model fits to the afterglow lightcurves indicate that the observed bright optical afterglows with R=13.00 mag at the peak time is consistent with predictions of the reverse shock and forward shock emission of external shock models.

➢ Introduction

Prompt optical and reverse shock optical emission are essential for revealing the jet radiation physics, composition, environment, and the properties of the central engine of the gamma-ray burst phenomenon, they were clearly detected only in a few GRBs (Melandri et al. 2008; Gomboc et al. 2009; Oates et al. 2009; Zhang et al. 2003; Gao et al. 2015). We report our observations of very bright prompt optical and reverse shock optical emission of GRB 140512A, and analyze its multi-wavelength data to study the jet properties of this GRB. The details of our analysis refer to Huang et al. (2016).

➢ Data analysis

The multi-wavelength lightcurves of GRB 140512A and our empirical fits are shown in Figure 1. The first optical data point may be contributed to the prompt optical emission. The temporal features of the early optical lightcurve is well consistent with the prediction of the reverse and forward shock emission models. Interestingly, the X-ray afterglow lightcurve can be also fit with the same model. With simultaneous multi-wavelength data, we extract the joint spectra in four selection slices as marked in Figure 1. We found that these spectra can be well fit with an absorbed single power-law function by considering both the optical extinction and neutral hydrogen absorption from Galaxy and the GRB host galaxies.

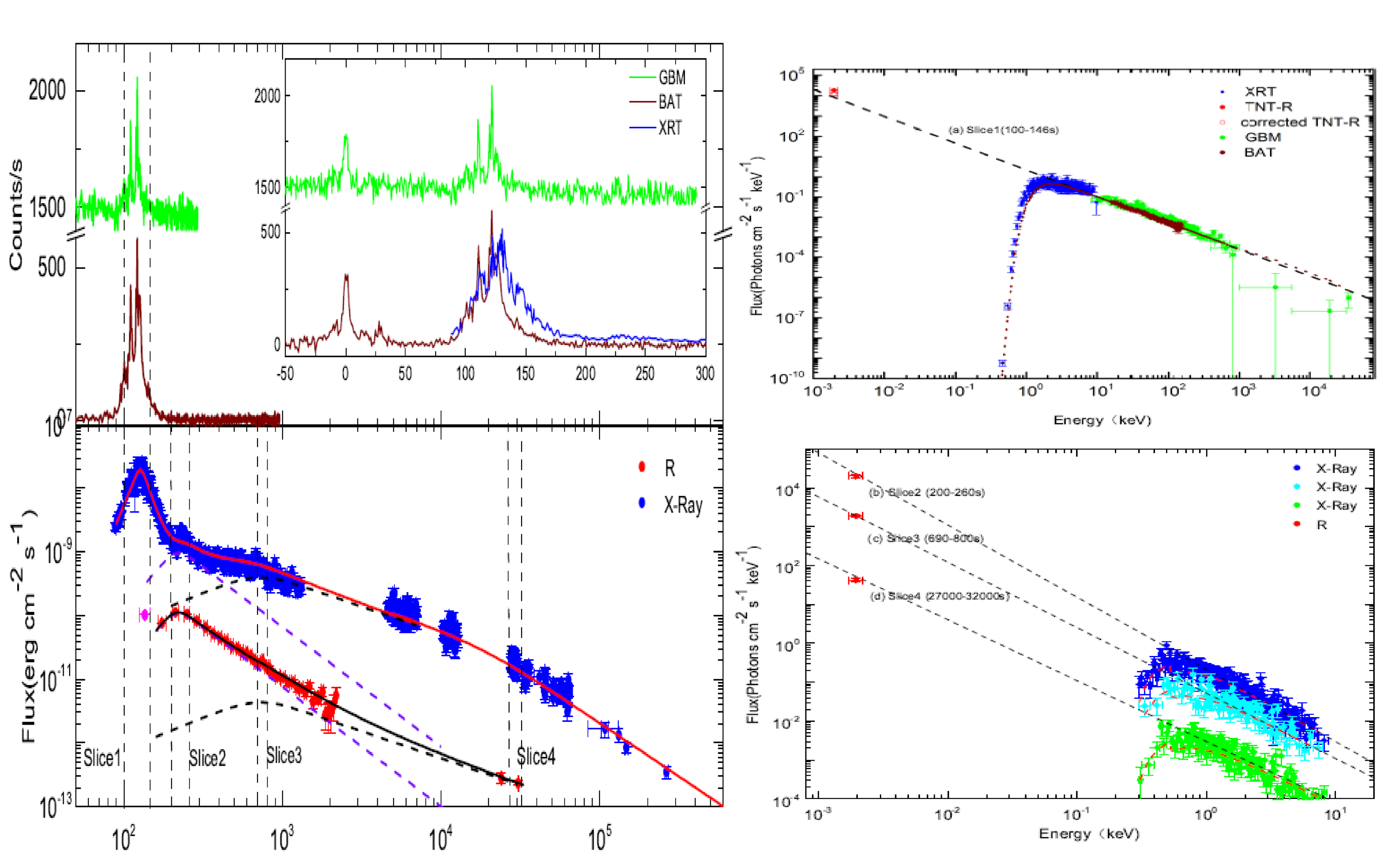

Fig. 1.—left panels—Multi-wavelength lightcurves with our empirical fit of GRB 140512A .The vertical dashed lines make the time slices of interest for our spectral analysis as shown in right panels. Right panels — Spectral energy distributions of the prompt gamma-ray-Optical-X-ray emission in Slice 1 and the afterglow emissions in Slices 2, 3, and 4.

➢ Theoretically Modeling the Afterglow Lightcurves

We present theoretical fits to the optical and X-ray afterglow lightcurves with the reverse shock and forward shock emission models. With a Markov Chain Monte Carlo algorithm we find that the following model parameter set can well represent the data,

$E_{K,iso}$=(7.65±0.18) x 10^{54} erg; Γ_0=112.3±0.9 ;

n=(9.7±0.4) cm^{-3} ; θ_j=(0.031±0.007) rad;

$\epsilon_{e,f}$ =0.29±0.08; $\epsilon_{B,f}$ =($1.82^{+0.63}_{-0.84}$) x 10^{-8};

$\epsilon_{e,r}$=0.006±0.002; $\epsilon_{B,r}$ =(1.49±0.06) x 10^{-4}.

We find a high magnetization degree in the reverse shock region with $R_B \equiv \epsilon_{B,r}/\epsilon_{B,f}$ =8187 and a relative low radiation efficiency with $R_e \equiv \epsilon_{e,r}/\epsilon_{e,f}$=0.02. Clear reverse shock emission is also observed in GRBs 990123, 090102, and 130427A. We also fit their early optical afterglow lightcurves with the same model by keeping $\epsilon_{e,r}$ and $\epsilon_{B,r}$ the same as that derived from GRB 140512A and varying the parameters of $E_{K,iso}$, n, p, and Γ_0, showing that the R_B of GRBs 990123, 090102, and 130427A are similar to that of GRB 140512A and their apparent difference may be mainly attributed to the difference of the jet kinetic energy, initial Lorentz factor, and medium density among them.

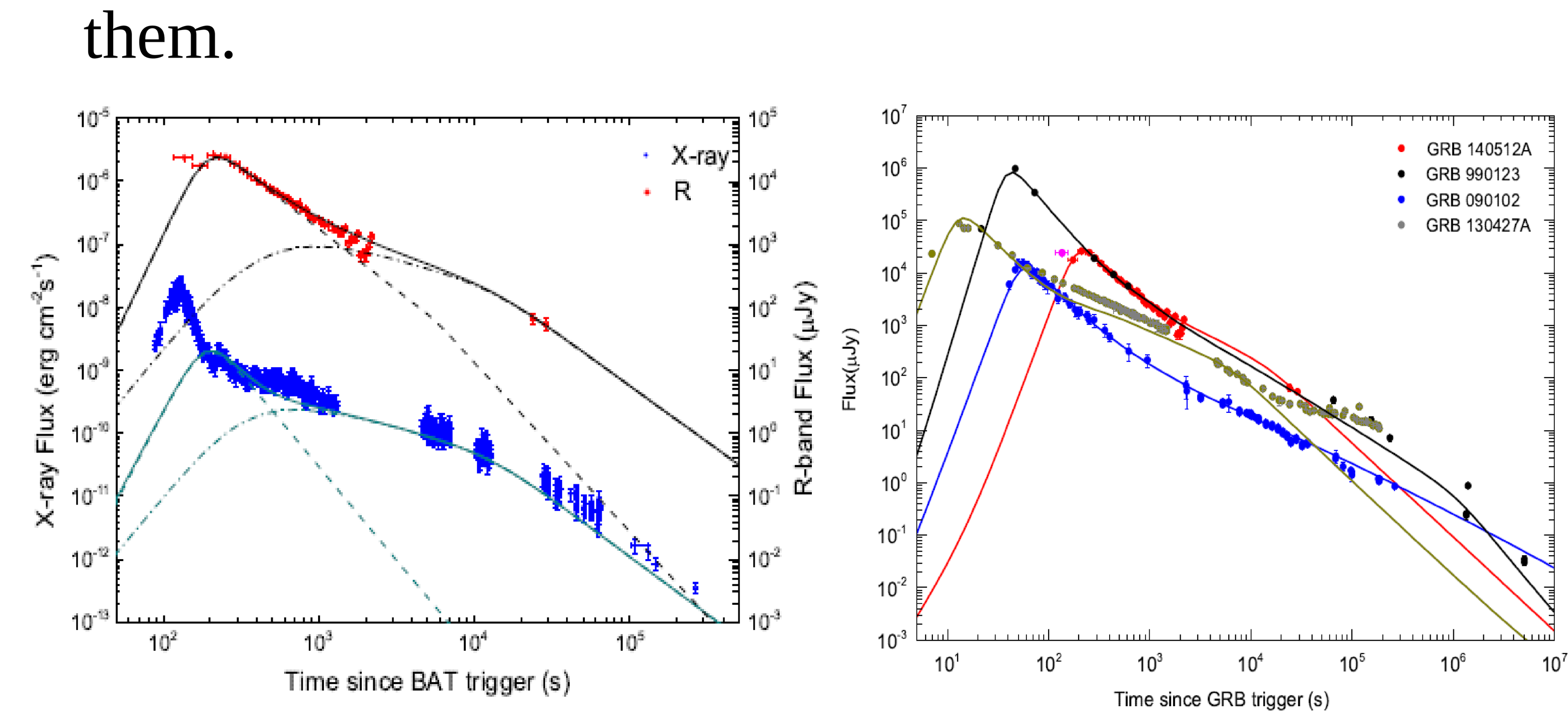

Fig. 3.— Left panel—Theoretically fits (solid lines) to the optical and X-ray afterglow lightcurves with external shock models by considering emission from both reverse (dashed lines) and forward shocks (dot-dashed lines).Right panel—Comparison of the GRB140512A afterglow lightcurves with GRBs 990123, 090102, and 130427A.

➢ Referencence

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