Final Summary of Research
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Title: Theoretical Studies of Gamma-Ray Bursts with Swift
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Graduate student L.J. Gou, P. Meszaros, T. Abel and B. Zhang investigated the detectability of long GRB afterglows from very high redshifts, where bright reverse shock emission last longer in the observer frame, and its importance for detection and analysis purposes relative to the forward shock increases. They consider two different models for the GRB environment, based on current ideas about the redshift dependence of gas properties in galaxies and primordial star formation. They calculate the observed flux as a function of the redshift and observer time for typical GRB afterglows, taking into account intergalactic photoionization and Lyman-alpha absorption opacity as well as extinction by the Milky Way Galaxy. The fluxes in the X-ray and near IR bands are compared with the sensitivity of different detectors such as Chandra, Swift and JWST. They find that Chandra and Swift can potentially detect GRBs out to very high redshifts z above 13 and 30, respectively. In the K and M bands, the JWST and ground-based telescopes are potentially able to detect GRBs even one day after the trigger out to z approximately 16 and 33, if present. While the X-ray band is insensitive to the external density and to reverse shocks, the near IR bands provides a sensitive tool for diagnosing both the environment and the reverse shock components.

P. Meszaros and M.J. Rees (Cambridge) investigated Gamma-ray bursts as X-ray depth-gauges of the Universe. They discuss the X-ray flux of gamma-ray burst afterglows at redshifts in the range 3-30, including the effects of the intergalactic He II absorption. They point out that strong X-ray lines may form locally in burst afterglows starting minutes after the trigger. This can provide distinctive X-ray distance indicators out to the redshifts where the first generation of massive stars form.

Bing Zhang, Shiho Kobayashi and Peter Meszaros studied the Gamma-ray burst early optical afterglow implications for the initial Lorentz factor and the central engine. Early optical afterglows have been observed from GRB 990123, GRB 021004, and GRB 021211, which reveal rich emission features attributed to reverse shocks. It is expected that Swift will discover many more early afterglows. Here we introduce a straightforward recipe for directly constraining the initial Lorentz factor of the fireball using the combined forward and reverse shock optical afterglow data. The scheme is largely independent of the shock microphysics. We identify two types of combinations of the reverse and forward shock emission, and explore their parameter regimes. We also discussed a possible diagnostic for magnetized ejecta.

Z.G.Dai (Nanjing U, China), B. Zhang, L. J. Gou, P. Meszaros (Penn State) and E. Waxman (Weizmann) studied the GeV Emission from Blazars and its relation to the Intergalactic Magnetic Fields. Blazars and AGN are part of a secondary hard X-ray survey planned for Swift. Several high-frequency peaked BL Lac objects such as Mrk 501 are strong TeV emitters. However, a significant fraction of the TeV gamma-rays emitted are likely to be absorbed in interactions with the diffuse IR background, yielding electron-positron pairs. We studied the inverse-Compton scattering of cosmic microwave photons by the resulting electron-positron pairs, which implies the existence of a hitherto undiscovered GeV emission. The typical duration of the GeV emission is determined by the flaring activity time and the magnetic deflection time. We numerically calculated the scattered photon spectrum and find a spectral turnover and flare duration at GeV energies which are dependent on the field strength. The GeV flux levels predicted should be detectable with GLAST for intergalactic fields below 1E-16 G, as expected in voids.

References:

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PATENTS resulting from this work: None