Einstein Probe GRB transients: jet-environment interactions and viewing angle explain their diversity

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The Einstein Probe (EP), launched in 2024, was designed to explore the dynamic X-ray sky and advance our understanding of gamma-ray bursts (GRBs) and stellar explosions. With its sensitivity to soft X-rays and rapid localization capability, EP, together with extensive multi-wavelength follow-up campaigns, has uncovered a growing sample of GRB-related events. Observations from the earliest stages of these explosions have revealed a remarkable diversity of transients emerging on timescales of hours to weeks after the trigger, pointing to a wide range of jet properties, progenitor structures, and circumstellar environments. However, most of these events have been interpreted individually, and a global physical framework connecting them to one another and to the broader GRB population is still lacking. Here, we present a systematic analysis of the EP transient sample discovered to date within a unified theoretical framework that follows the interaction of relativistic jets with progenitor stars and surrounding circumstellar material. We show that much of the observed diversity can be understood through variations in a few key physical parameters: jet energy, extent of circumstellar material, and observer viewing angle. These parameters naturally produce on-axis jets, off-axis jets, and barely failed jets, giving rise to classical GRBs with bright afterglows, GRBs with initially rising afterglows, and soft GRBs accompanied by fast blue optical transients, respectively. This framework identifies the observational signatures of different jet outcomes and provides a physical basis for interpreting current EP discoveries and predicting future transients.