Physics Colloquium

Michigan Technological University

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Room 139 Fisher Hall

Heterogeneity in Short Gamma-Ray Bursts

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Abstract: GRBs, briefly the most powerful explosions since the Big Bang, come in at least two types, as distinguished by their stellar-system progenitors. Long bursts (duration ~> 2 s) -- widely believed to arise from core collapse of rapidly rotating massive, metal-poor stars -- are found preferentially internal to small irregular galaxies at early epochs, in regions with enhanced star formation. Where sub-arcsecond localizations are available for short bursts, they do not indicate such a preference. Instead, nuclear offsets -- sometimes placing the source outside the galaxy -- seem to favor no particular galaxy type, nor epoch, but do favor a timescale consistent with coalescence of compact-object binary systems (~ 1 Gyr). Whether a dichotomy in offsets is definitive -- clouded by the often less accurate short-burst localizations -- is unclear, but it does suggest that short bursts may arise from two kinds of compact-object systems.

Short bursts themselves do appear dichotomous: three quarters are truly short, with durations <~ 2 s and robust evidence of absence in many cases of any gamma-ray component after the burst. The other quarter are accompanied by a very low-level extended emission (EE) component, with duration ~ 100 s. The two groups have markedly different prompt emission and X-ray afterglow timescales, and total energies: median durations, pulse structure widths, and peak intervals for EE bursts are factors of ~ 2–3 longer than for non-EE bursts. The median flux of X-ray afterglows at initial detection time for EE bursts is > 20 times brighter than for non-EE bursts, and the median X-ray afterglow duration for EE bursts is ~ 30 times longer than for non-EE bursts.

The tendency for EE bursts toward longer prompt-emission timescales and higher initial X-ray afterglow fluxes implies larger energy injections powering the afterglows. The longer-lasting X-ray afterglows of EE bursts suggest that a significant fraction explode into more dense environments than non-EE bursts, and/or that the sometimes-dominant EE component efficiently powers the X-ray afterglow. All things considered: Different progenitor systems are favored for EE and non-EE short bursts.

Bio: Dr. Jay Norris (BSU, Physics) has been an astronomer since he was told the Earth is round and there is "stuff up there" (age ~ 6). He began working on NASA missions with high-energy instrumentation in the late 70s, concentrating on gamma-ray detectors, and development and application of temporal analysis algorithms for nonstationary phenomena and recovery of information in low S/N data, especially: gamma-ray bursts. In the 2000s he began designing and building infrared cameras and rapid reaction observatories for correlated visible-IR/high-energy observing programs for GRB afterglows and blazars. With J.D. Scargle he developed the DISCAN algorithm, used to set the current limit on variation of the speed of light with energy -- and constrain some variants of quantum gravity -- via the short GRB 090510 as observed by Fermi. In his spare time he studies the time-dependent interrelationships of global phenomena, from economics to climatology. He lives on a ranch in the wilderness in central Idaho, with his wife, dog, cat, and four miniature horses.