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Relativistic Self-Similar Solutions: Explosions, Implosions and Shock Breakouts.

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Self similar solutions provide a powerful analytical tool to examine strong explosions and implosions. We review several recent advancements in the understanding of such solutions, and focus on the relativistic regime. Surprisingly, in the relativistic regime the equations are simple, and allow fully analytical treatment. We derive self-similar solutions for ultrarelativistic shock waves propagating into cold material of power law density profile in radius. We treat both implosions and explosions in three geometries: planar, cylindrical, and spherical. For spherical explosions these are the first type solutions of Blandford and McKee for slowly decreasing density; they are new solutions of the second type for steep density profiles. In addition we find new, hollow (with evacuated interior), first type solutions that may be applicable for some intermediate regime. Interestingly, there is a range of density profiles for which current considerations allow for both hollow first and second type solutions. Further understanding is needed to determine which of the two solutions apply in this overlap regime. We provide similar exploration for the other geometries and for imploding configurations. New compound solutions, that contain both relativistic and non relativistic fluids are discussed. Those are non self-similar in their entirety, but are instead composed of two parts, each of which is self-similar. We show how these new solutions are used to explore strong relativistic shock waves emerging from the surface of a star.