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Physical Significance of the Constants in the Colliding Plane Gravitational Wave Solutions

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Solutions of the usual wave equation involve two arbitrary constants since it is a
linear second order ordinary differential equation. Physically, these constants represent the amplitude and frequency of the waves. It is not a priori clear that "nonlinear wave equations" must possess two constants as well. However, the exact solutions of the nonlinear Einstein Field Equations for plane and cylindrical gravitational waves do involve two constants, and it is natural to assume that the constants have the same physical significance. The original "solutions for colliding plane gravitational waves — "impulsive" by Khan and Penrose and "sandwich" by Szekres — also involve two, while we may naively have expected four (two for each). The recently derived solution for "colliding plane gravitational waves of arbitrary strengths" was taken to possess two constants. Here we note that it actually possesses three constants, and probe their physical significance by investigating the momentum imparted to test particles by varying combinations of all three constants for both types of plane waves.

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