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Stability of self similar compressional waves with Hertzian nonlinearity

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Nonlinear compressional waves propagating into a granular medium such as the seafloor are subject to the Hertzian nonlinearity of order 3/2 in the strain rate. As a result, the coefficient of quadratic nonlinearity becomes arbitrarily large at low stress. Two theoretical problems result from the Hertzian nonlinearity: (1) the quadratic nonlinearity in the equation of state is no longer the lowest order one; and (2) questions of stability arise when nonlinear steepening occurs arbitrarily fast. We have previously derived a simple nonlinear wave equation model for compressional waves in granular media that resolves the problem of low order nonlinearity and diverging nonlinearity parameter. It is a variant of the nonlinear progressive wave equation (NPE) of McDonald and Kuperman [J. Acoust. Soc. Am. 81, 1406 - 1417, 1987]. Using this model we derive self similar wave profiles for fractional order nonlinearity $1 < n < 3$ and demonstrate their stability. Using a wave- following coordinate system we show that where the quadratic nonlinearity coefficient diverges, the slope of the self similar wave locally approaches zero. Work supported by the U. S. Office of Naval Research.