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A theoretical study of variable stars

A. T. M. Wijethunga* and P. A. A. Perera

Department of Physics, Faculty of Science, University of Kelaniya, Sri Lanka
*atmw169@gmail.com

A variable star is, quite simply, a star that changes its brightness with a certain regularity. The Energy required for pulsation stars' continuous operation is provided by a complex mechanism of transforming the thermal energy into the mechanical energy of pulsation. Pulsating stars can be considered as heat engines and must behave according to the same thermodynamic principles which are applicable to other thermodynamic heat machines. For most of the variable stars, the pulsating procedure consists of expansion and compression of the diameter of the stars and the energy is originated from a nuclear fusion reaction which involves H and He nuclei which are the main constituents of a typical main-sequence star. Study of pulsating stars is inherently interesting, because it is now understood that various properties of these stars can be used to determine some important cosmological distances. In the present research a simple numerical model, based on the principles of physics a typical undergraduate student learns, has been developed to explain the properties of Delta Cephei which is a prototype variable star with the observed pulsation period of 5 days, 8 hr, 48 min. The model predicts distinctly non-sinusoidal oscillations and very closely reproduces the observed period. The period "hiding" in the equations can lead to the technique of linearization and a discussion of how small departures from stable equilibrium result in simple harmonic motion. Using non-linearization and linearization methods, relationships between star mass and pulsating period has been found as follows.
Non-linearization,
$T = -0.54 Z5 + 0.42 Z4 + 0.27 Z3 + 0.57 Z2 - 1.6 Z + 3.3$; $Z = (M-1.4\times1031)/(4.8\times1030)$
Linearization,
$T = -0.42 Z5 + 0.66 Z4 - 0.035 Z3 + 0.27 Z2 - 1.5 Z + 3.3$; $Z = (M-1.4\times1031)/(4.8\times1030)$

Keywords: Delta Cepheid, equilibrium radius, pressure, pulsation time period, simple harmonic motion, surface velocity