NEWTONIAN STELLAR MODELS

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Abstract

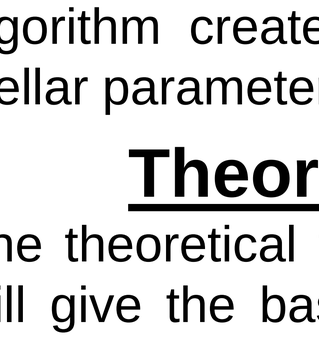
This work studies stellar parameters, based on equations and notions of theoretical physics, demonstrating how it is possible to obtain and understand the Lane-Emden equation, analyzing some aspects in a pedagogical way. A Python computational language was used, attached to a numerical resolution method known as Runge-Kutta;With these tools it was possible to build some graphics, which relates the stellar parameters with the indexed numbers of the theoretical model.

Introduction

The study and interest in stars can be traced back to the earliest civilizations, that culture used stars for agriculture and navagations. That use created a few questions, about the formation and evolution stellar, being answered over time, generating technologies and more research on the subject.
This work used the concepetions of Newtonian physics, one method of numerical resolution and a algorithm created in python language, to analize stellar parameters.

Theoretical Fundamental

The theoretical foundations of Newtonian physics will give the base for the next steps; By making use of three principal equations and some relations between them, could be possible obtain a fourth equation.
First it was defined the thickness of a shell, generating the equation of continuity of mass. The next step was to use a definition of pressure, and last to define an equation of polytropic state,, performing the appropriate algebraic operations., This way ,the Lane-Emden equation. Is obtained:



$$\frac{dP}{dr} = -\rho \frac{G\,M(r)}{r^2}$$

$$\frac{dM(r)}{dr} = \rho\, 4\pi\, r^2$$

$$P = K\rho^{\gamma} = K\rho^{\frac{n+1}{n}}$$

$$\frac{1}{\xi^2}\frac{d}{d\xi}\left(\xi^2 \frac{d\theta}{d\xi}\right) = -\theta^n$$

Numerical Solution

Firstly it's known that the Lane-Emden equation, is a non-linear differential equation. For solving its is necessary used a method of Runge- Kutta of order four. For building the algorithm (Anandaram,2013) suggested a change of variables, helping on visualization of the code and building of graphics.

Gráfico de n=3,0

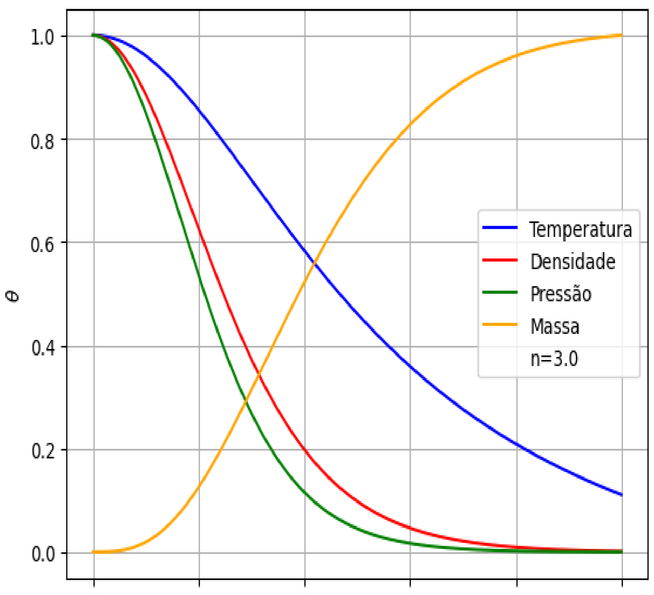


Gráfico de n=4,9

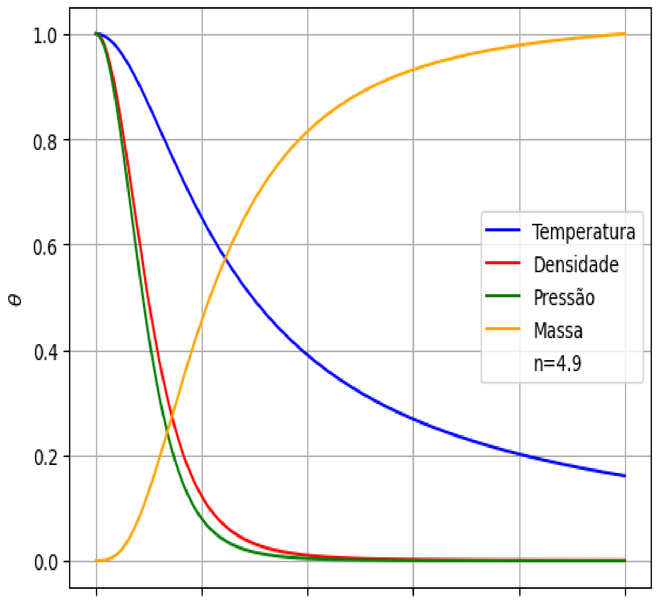


Gráfico do valor indexado em relação ao Raio

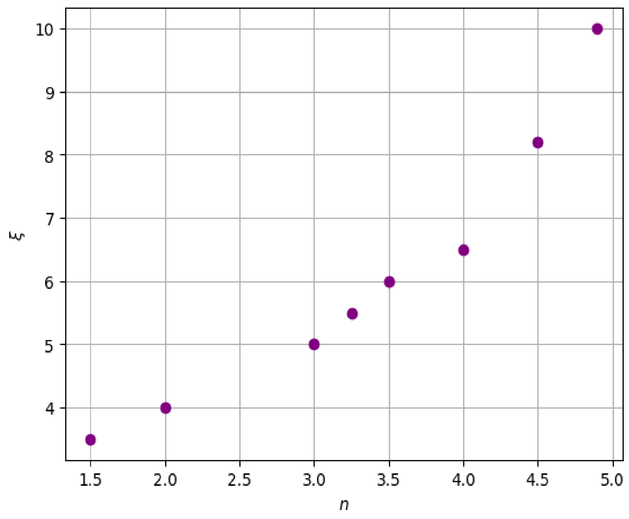
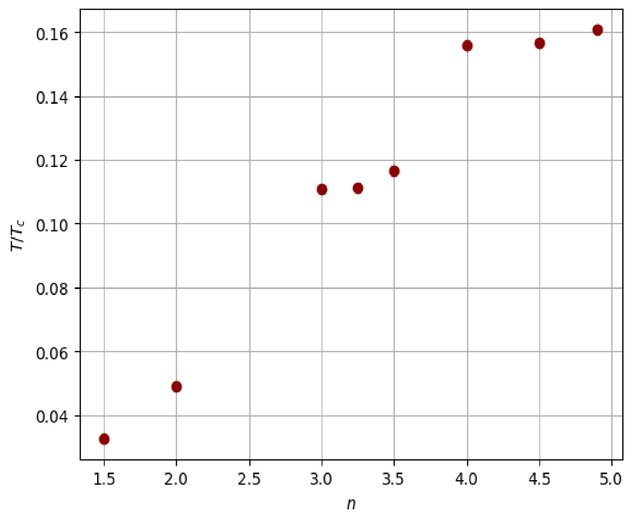


Gráfico do valor indexado em relação a Temperatura



Conclusion

Finally, it is concluded that the variations between parameters and the polytropic index are of great help; Based on this relationship, it becomes possible to analyze different types of stars, using the radius and temperature.

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