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EOS Summary

Aman Agarwal[1, 2]

[1] Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada, N2L 2Y5
[2] Department of Physics, University of Guelph, Guelph, Ontario, Canada, N1G 2W1

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1. HELMHOLTZ EOS

These will be notes condensed from Timmes & Swesty (2000)

They got an electron-positron equation of state based on table interpolation of Helmholtz free energy using biquintic Hermite polynomials. Direct evaluation of the EOS would be time consuming as over 10^9 calls will be made in a 2D or 3D hydrodynamical simulation. However table interpolation has to be done with enough resolution and should be thermodynamically consistent(i.e. satisfy Maxwell's equations)[Eq 2,3 and 4 in Timmes & Swesty (2000)]

*Thermodynamic inconsistency may manifest itself in the unphysical buildup (or decay) of the entropy (or temperature) during numerical simulations of what should be an adiabatic flow.*Timmes & Swesty (2000)

$$F = E - TS, \;\; dF = SdT - \frac{P}{\rho^2} d\rho \tag{1}$$

With this definition of Helmholtz Free energy if we define our pressure and entropy as:

$$P = \rho^2 \frac{\partial F}{\partial \rho}\bigg|_T \tag{2}$$

$$S = -\frac{\partial F}{\partial T}\bigg|_\rho \tag{3}$$

we can interpolate a give $F(\rho, T)$ table with any interpolating function (which lets derivatives of density and temperature commute) and it will be thermodynamically consistent, however wrong the interpolation maybe.

2. SECTION 2

Lorem Ipsum

REFERENCES

Timmes, F. X., & Arnett, D. 1999, ApJS, 125, 277, doi: 10.1086/313271

Timmes, F. X., & Swesty, F. D. 2000, ApJS, 126, 501, doi: 10.1086/313304