

LA-UR-20-30467

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Title: Sound Speed Calculations in EOSPAC6

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Intended for: Report

Issued: 2020-12-23

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Sound Speed Comparisons in EOSPAC6

Daniel Sheppard

Are all thermodynamic relations created equal?

Black: direct interpolation

Green: inverted with respect to second variable

Blue: constructed from two other tables

eospac6 calls

• eos_Pt_DT, eos_Ut_DT

• eos_Pt_DUt

• eos_T_DUt, eos_Pt_DT

• eos_Pt_DSt

• eos_St_DPt

sound-speed derivation

$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_T + \frac{T}{\rho^2 \left(\frac{\partial U}{\partial T}\right)_\rho} \left(\frac{\partial P}{\partial T}\right)_\rho^2$$

$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_U + \frac{P}{\rho^2} \left(\frac{\partial P}{\partial U}\right)_\rho$$

$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_T + \left(\frac{\partial P}{\partial T}\right)_\rho \left[\left(\frac{\partial T}{\partial \rho}\right)_U + \frac{P}{\rho^2} \left(\frac{\partial T}{\partial U}\right)_\rho \right]$$

$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_S$$

$$c^2 = \frac{-\left(\frac{\partial S}{\partial \rho}\right)_P}{\left(\frac{\partial S}{\partial P}\right)_\rho}$$

eq. label

(1) Menikoff

(2) FLAG

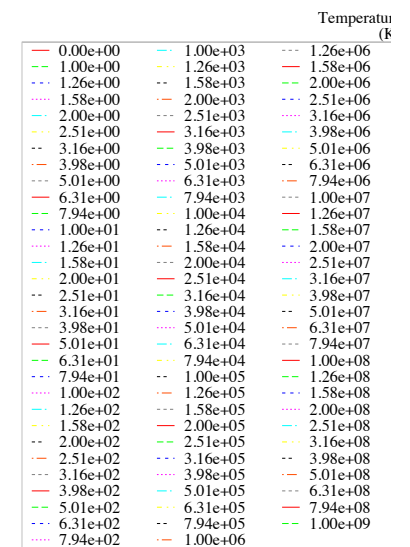
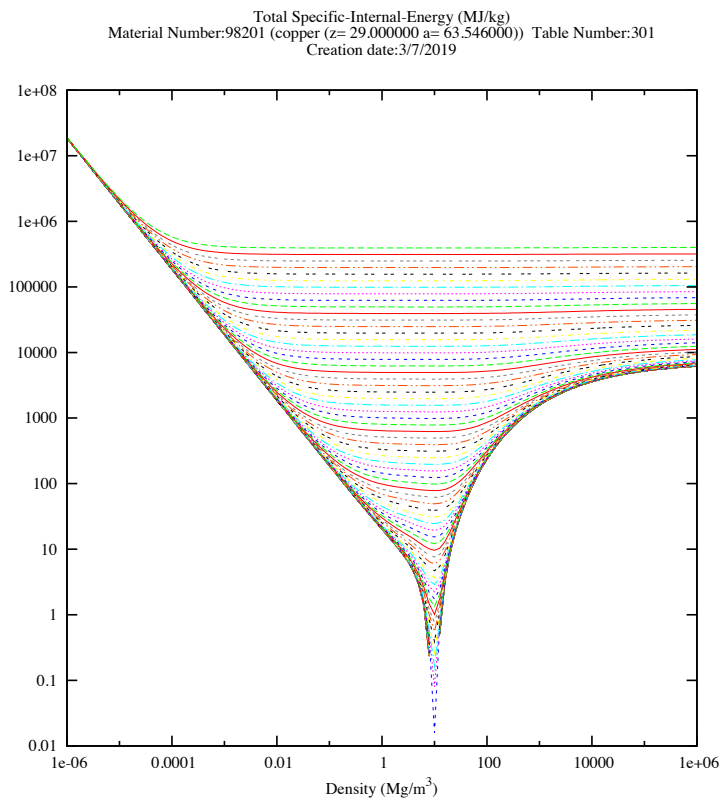
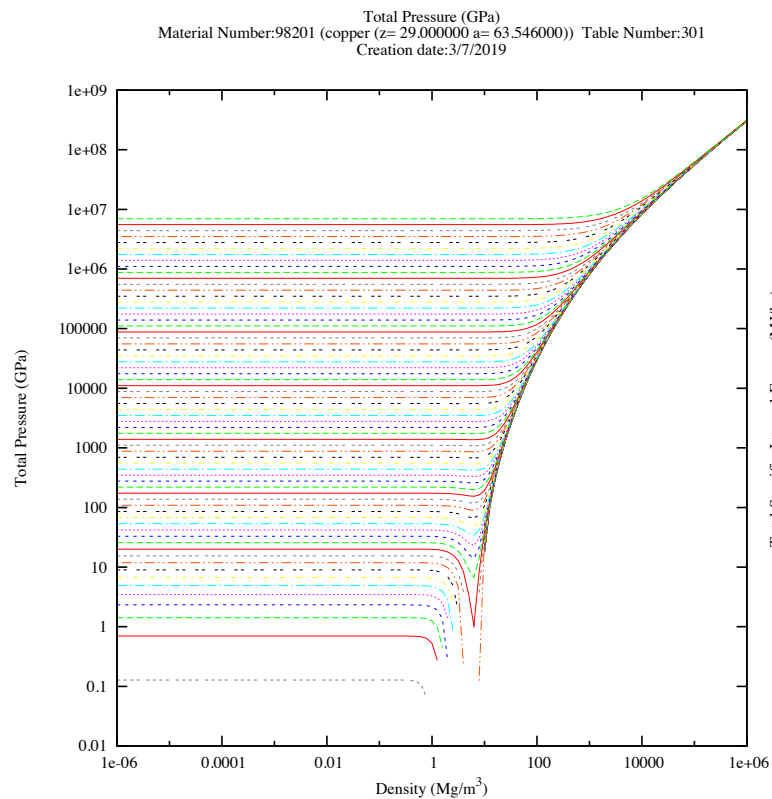
(3) Peterson

(4) entropy

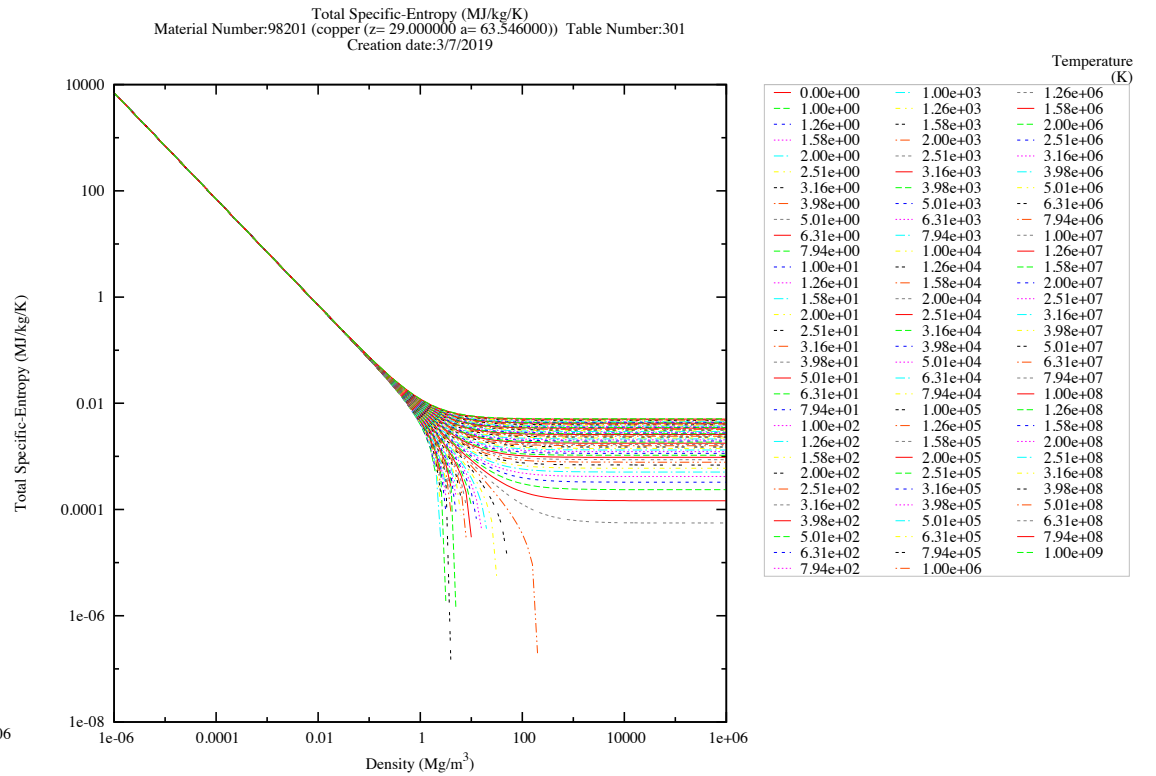
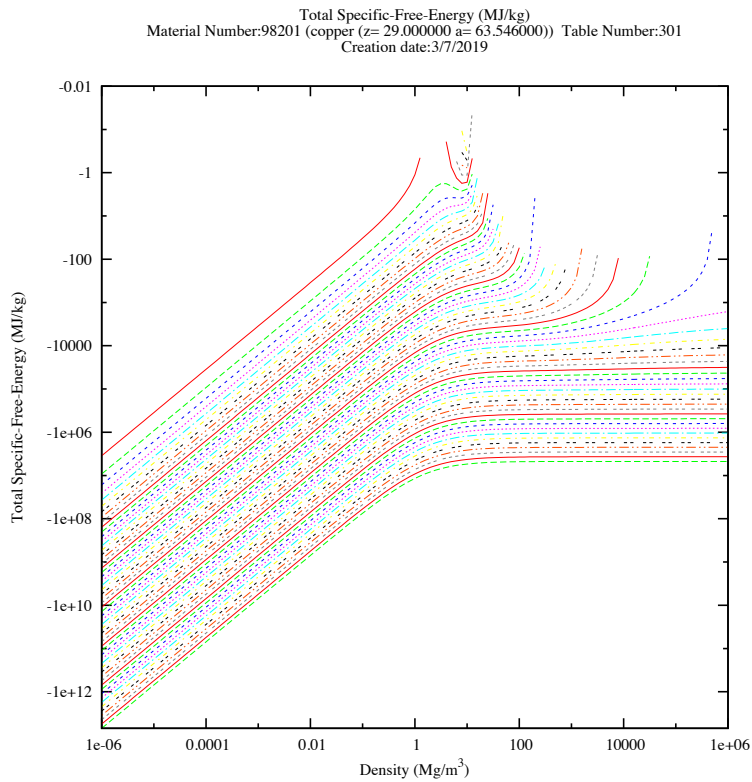
(5) entropy2

Test case 1: Analytic copper: MATID = -8201

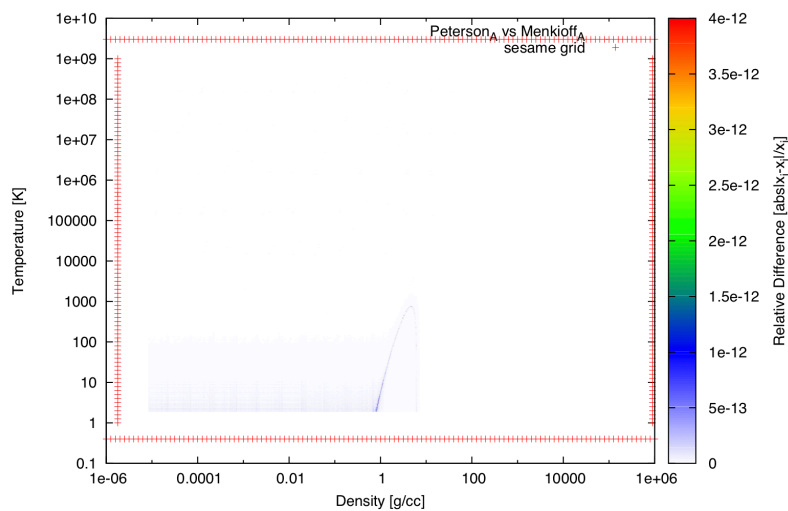
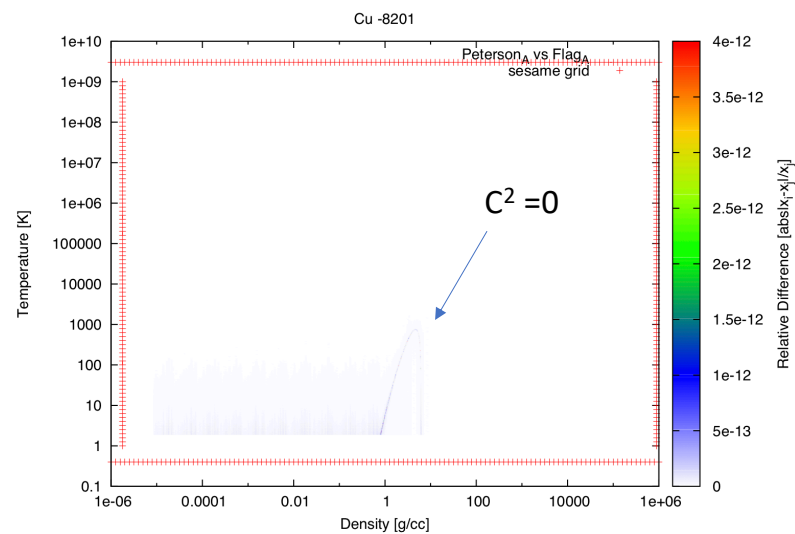
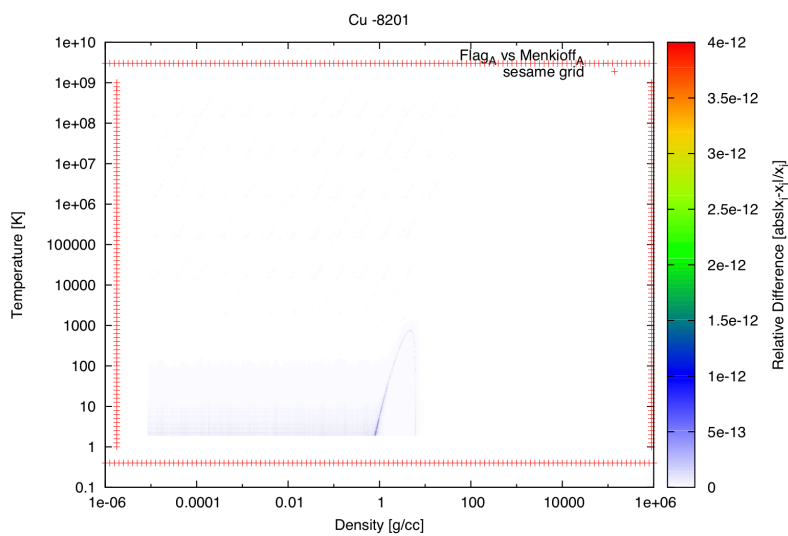
Pressure/Density and Energy Density



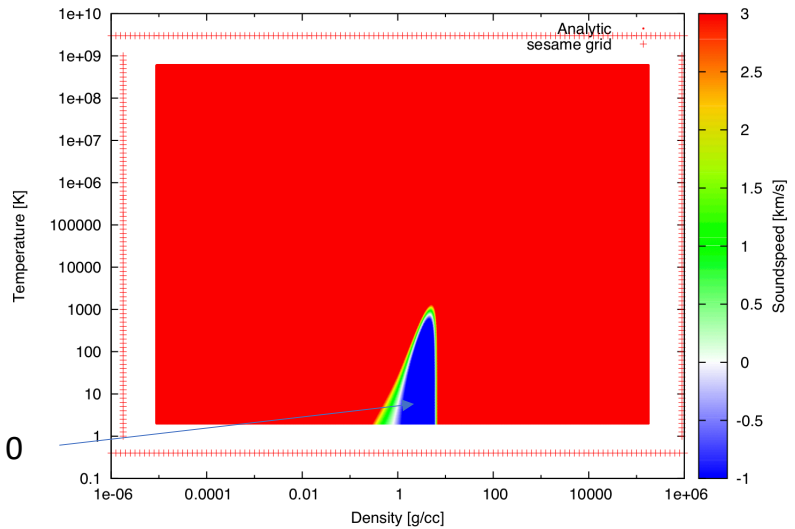
Helmholtz/Density and Entropy/Density



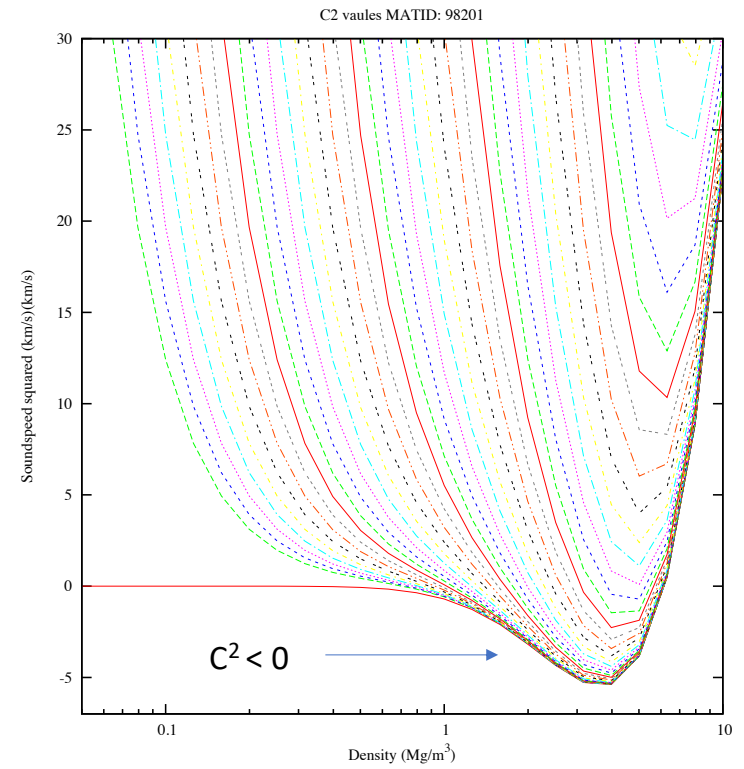
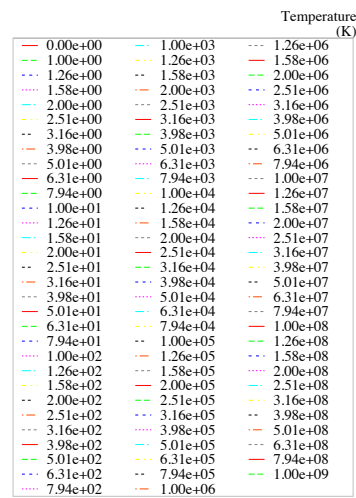
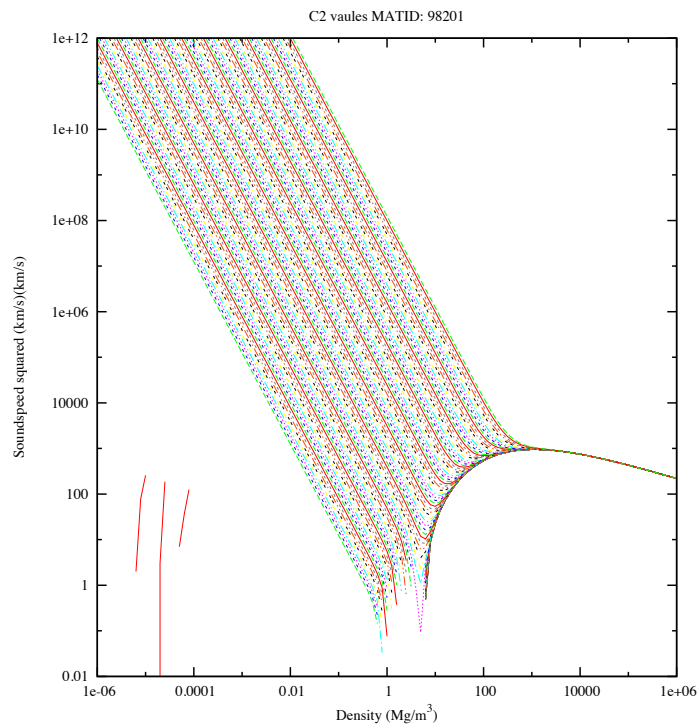
Analytic comparisons



$C^2 < 0$

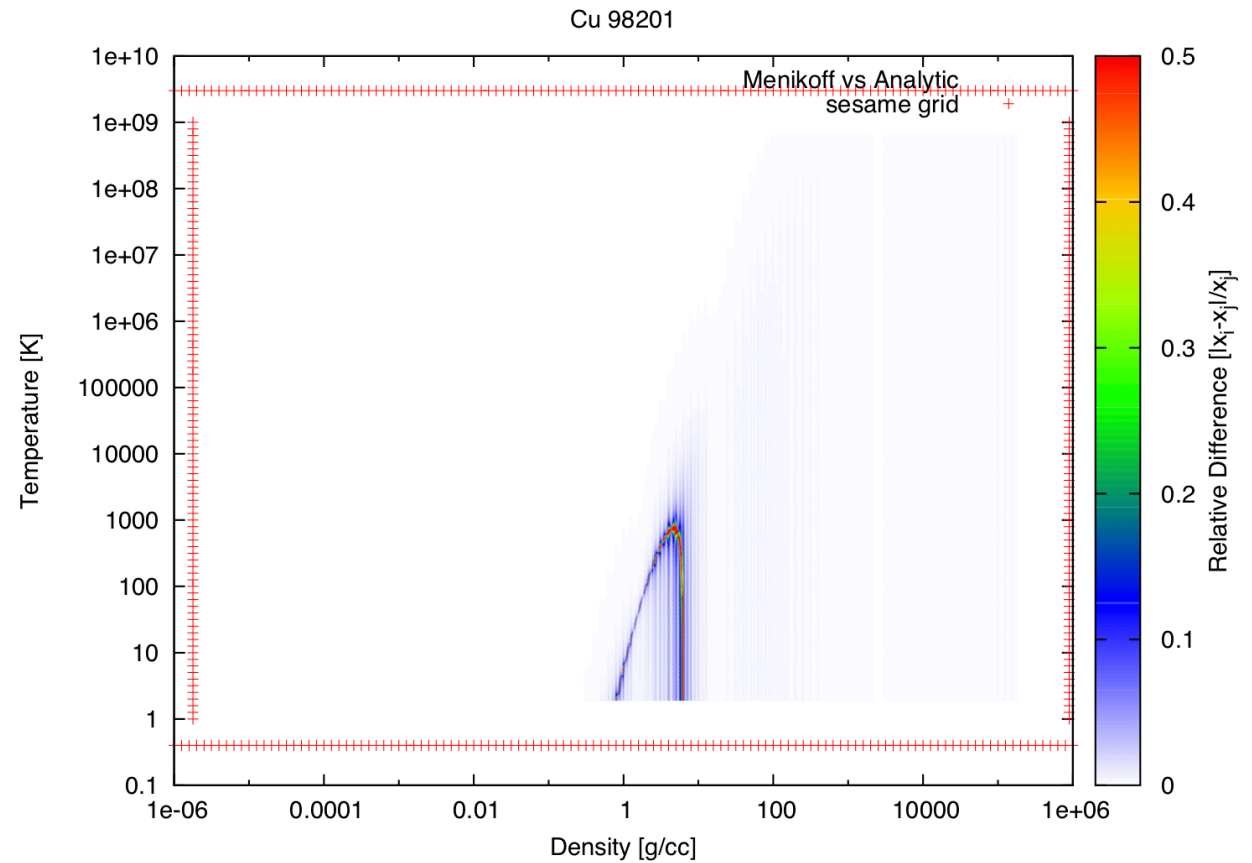


C² vs Density

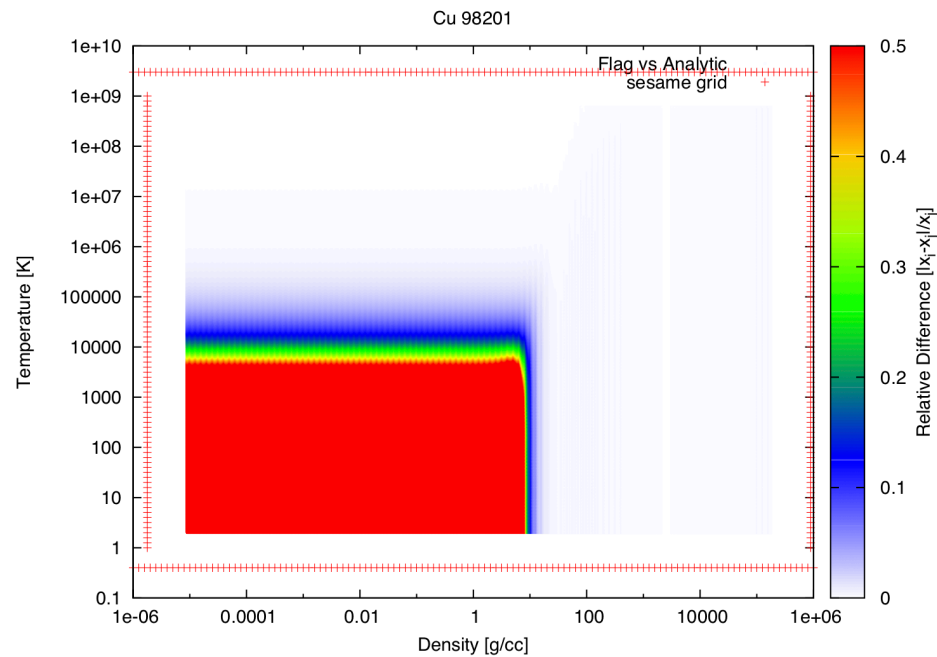


Menikoff does the best in expansion

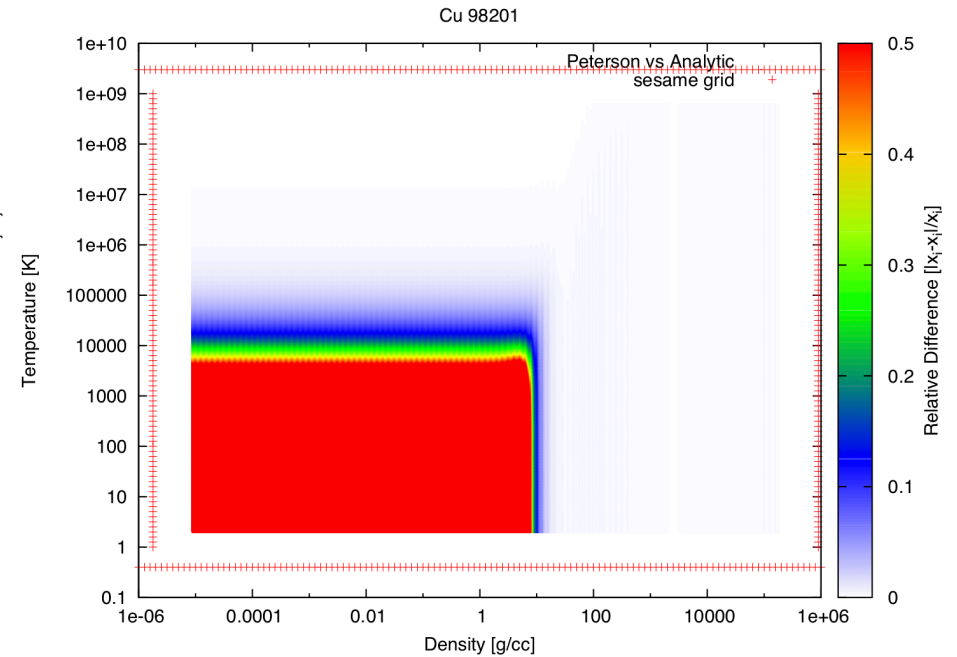
$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_T + \frac{T}{\rho^2} \left(\frac{\partial U}{\partial T}\right)_\rho \left(\frac{\partial P}{\partial T}\right)_\rho^2$$



Flag and Peterson: bad in expansion?



$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_U + \frac{P}{\rho^2} \left(\frac{\partial P}{\partial U} \right)_\rho$$



$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_T + \left(\frac{\partial P}{\partial T} \right)_\rho \left[\left(\frac{\partial T}{\partial \rho} \right)_U + \frac{P}{\rho^2} \left(\frac{\partial T}{\partial U} \right)_\rho \right]$$

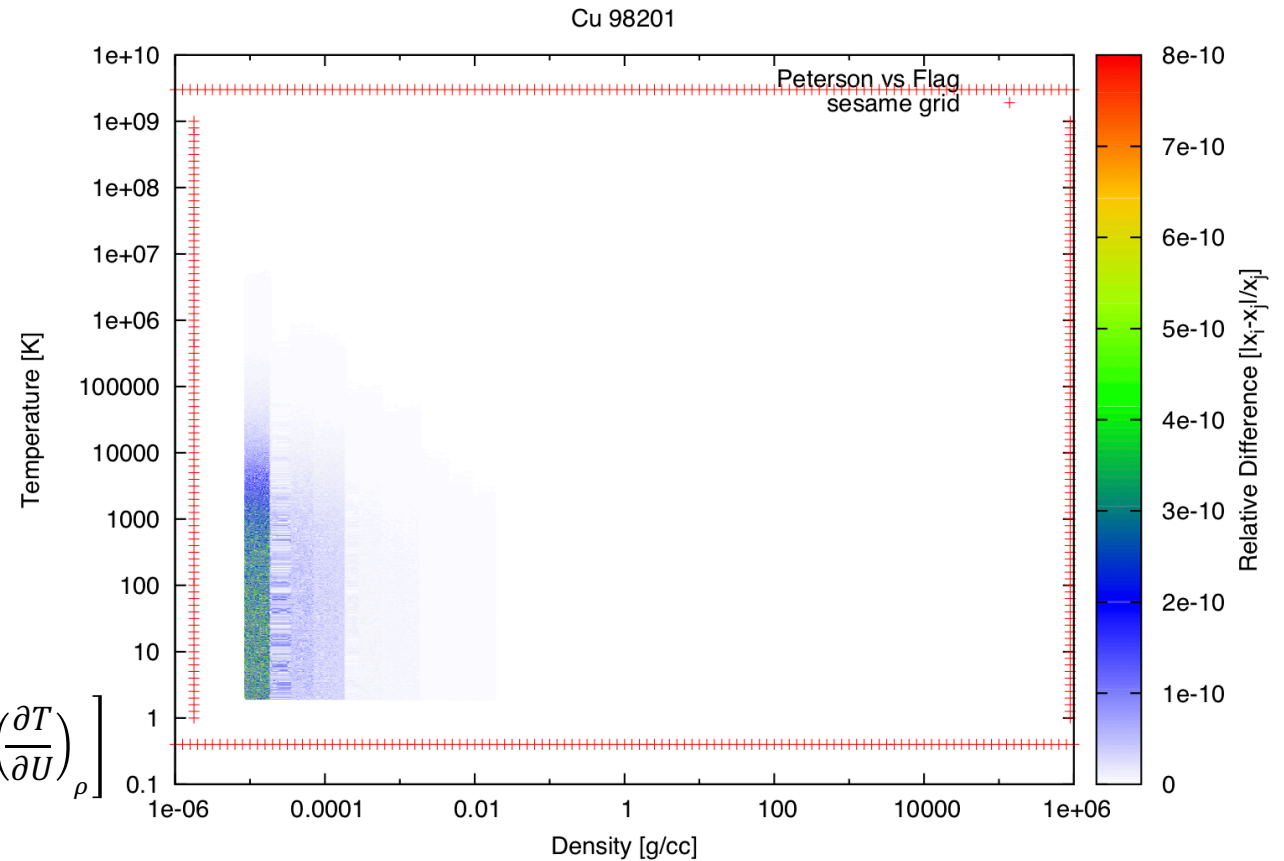
Peterson vs Flag are numerically consistent

FLAG

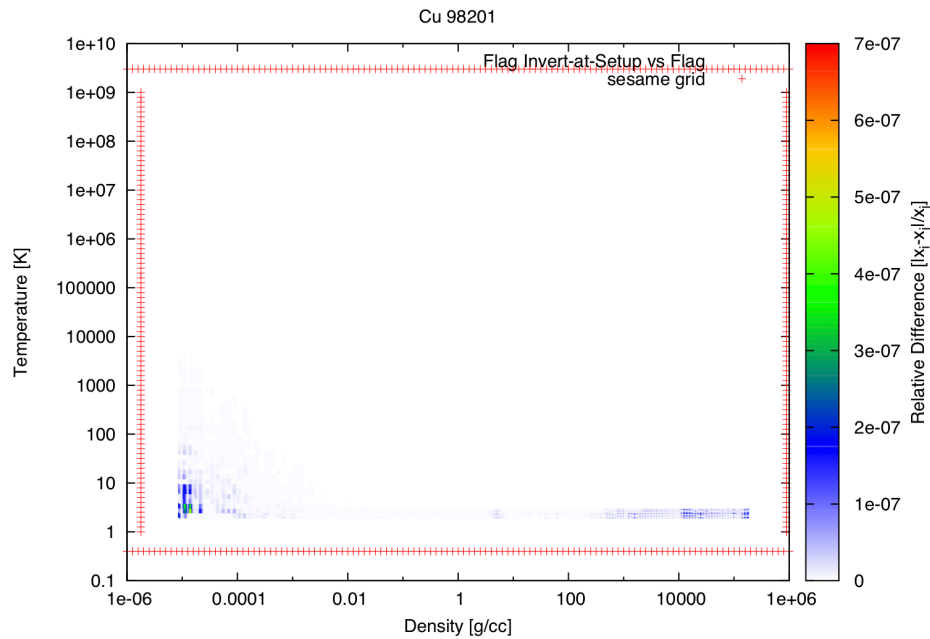
$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_U + \frac{P}{\rho^2} \left(\frac{\partial P}{\partial U}\right)_\rho$$

Peterson

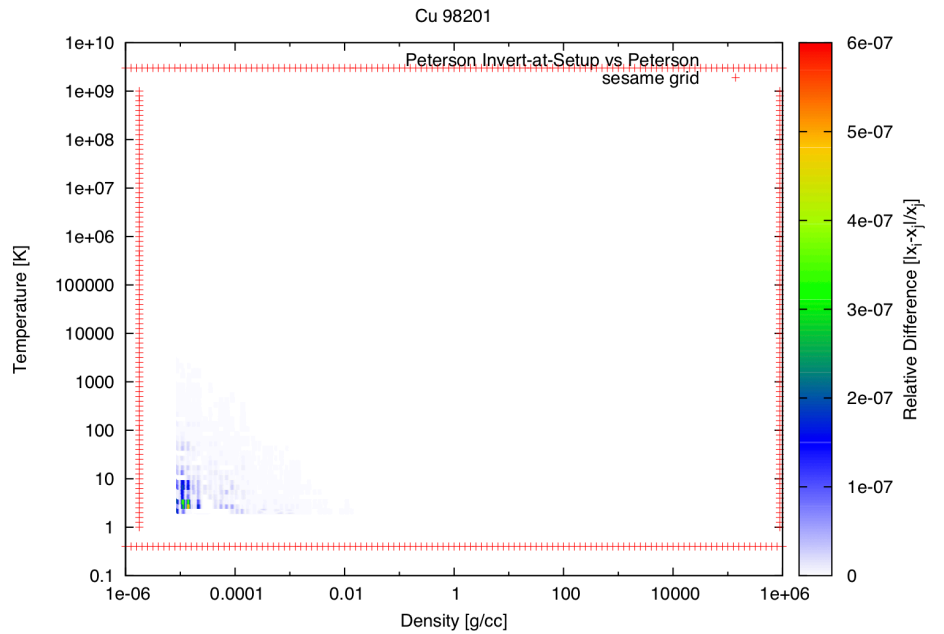
$$c^2 = \left(\frac{\partial P}{\partial \rho}\right)_T + \left(\frac{\partial P}{\partial T}\right)_\rho \left[\left(\frac{\partial T}{\partial \rho}\right)_U + \frac{P}{\rho^2} \left(\frac{\partial T}{\partial U}\right)_\rho \right]$$



Default interpolation vs. Invert_At_Setup

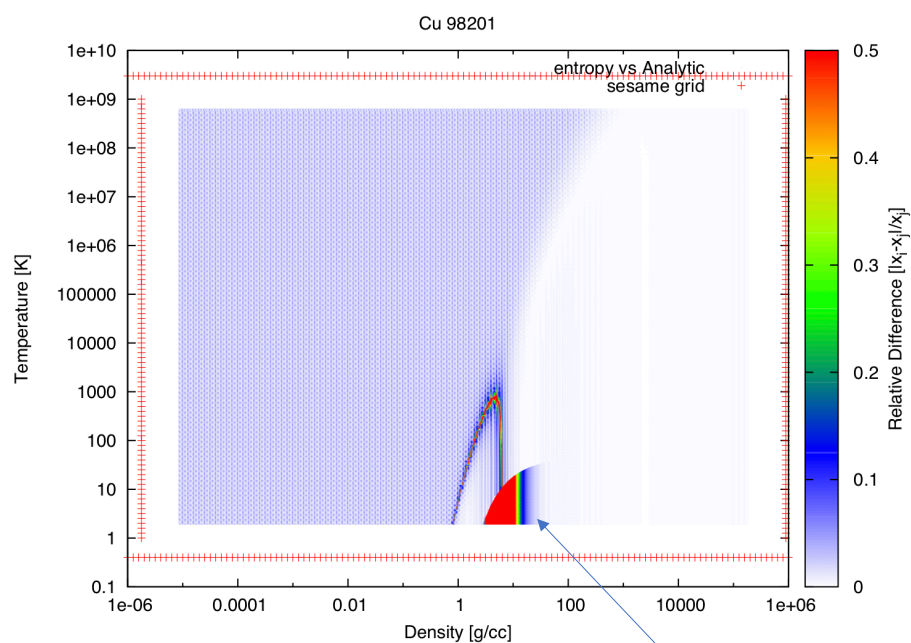


$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_U + \frac{P}{\rho^2} \left(\frac{\partial P}{\partial U} \right)_\rho$$



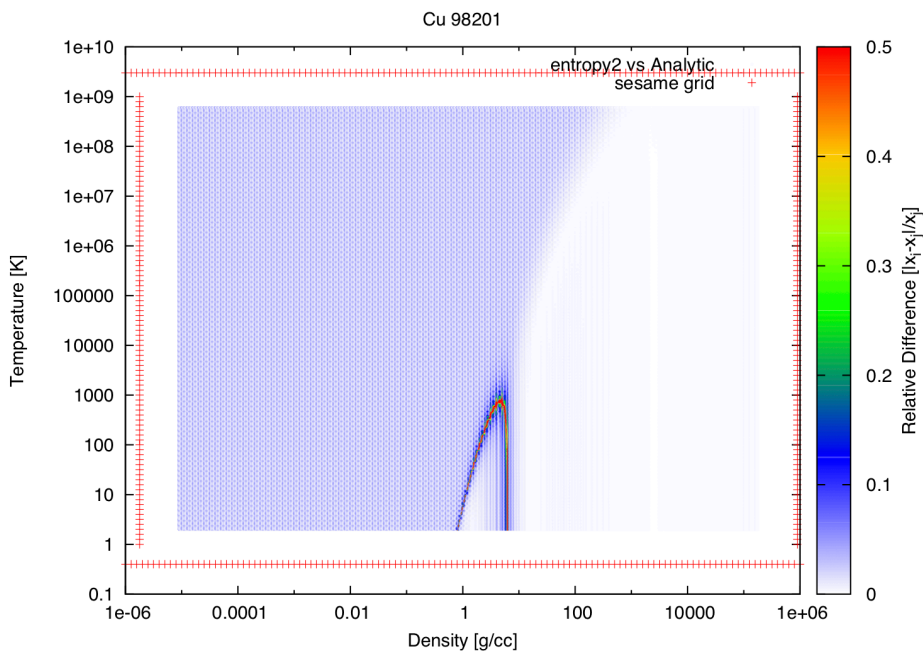
$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_T + \left(\frac{\partial P}{\partial T} \right)_\rho \left[\left(\frac{\partial T}{\partial \rho} \right)_U + \frac{P}{\rho^2} \left(\frac{\partial T}{\partial U} \right)_\rho \right]$$

Auto generated entropy tables for C²



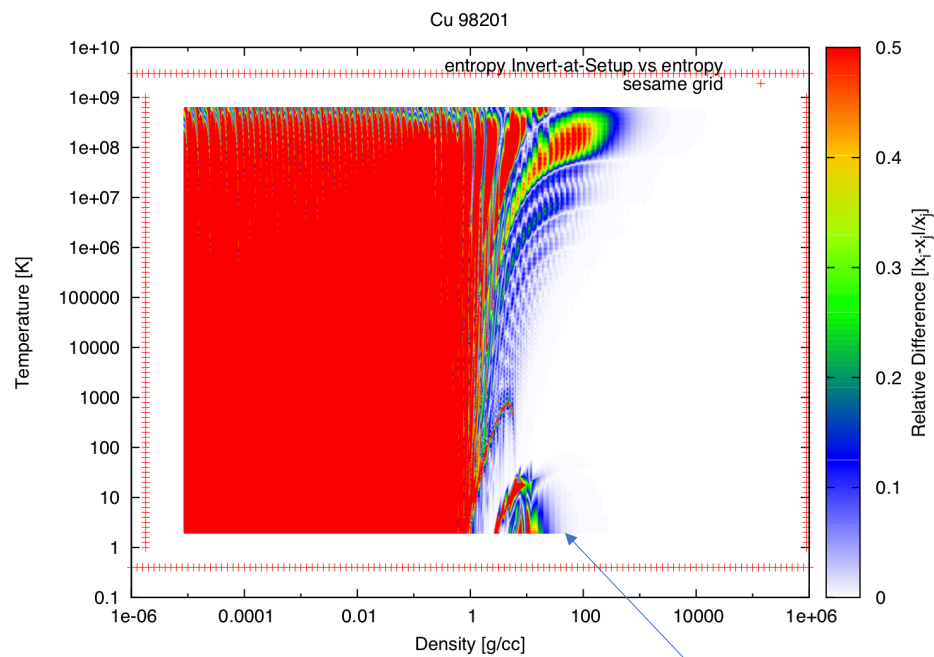
$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_S$$

Extrapolation



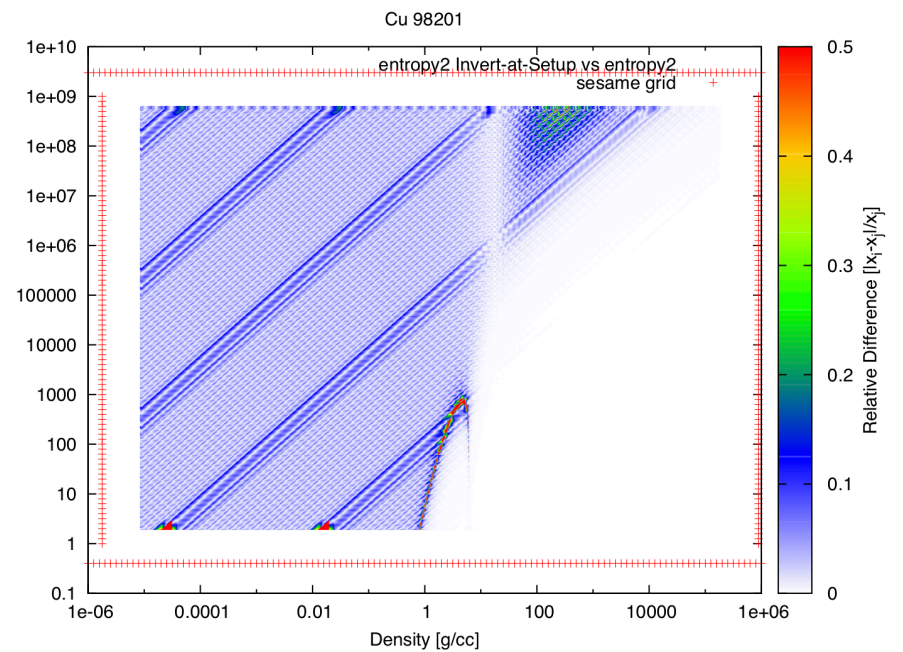
$$c^2 = \frac{-\left(\frac{\partial S}{\partial \rho}\right)_P}{\left(\frac{\partial S}{\partial P}\right)_\rho}$$

Invert_At_Setup entropy tables for C²



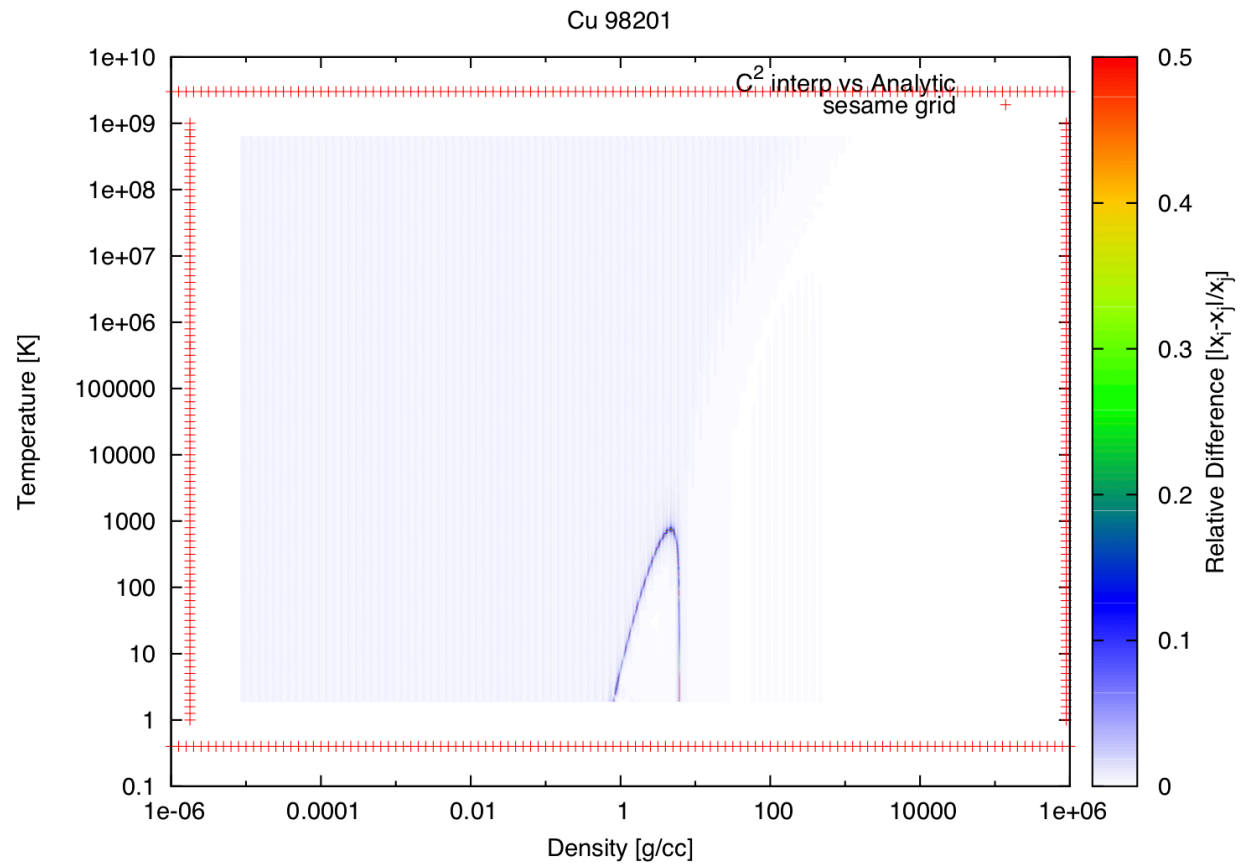
$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_s$$

Extrapolation



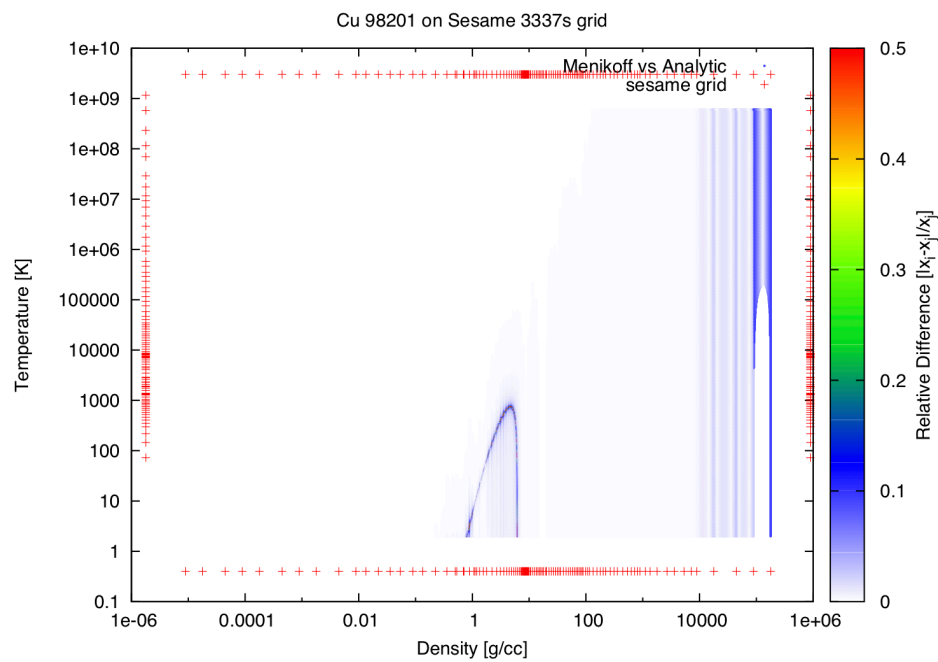
$$c^2 = \frac{-\left(\frac{\partial S}{\partial \rho} \right)_P}{\left(\frac{\partial S}{\partial P} \right)_\rho}$$

Direct Tabulation of C^2 in 300 style table

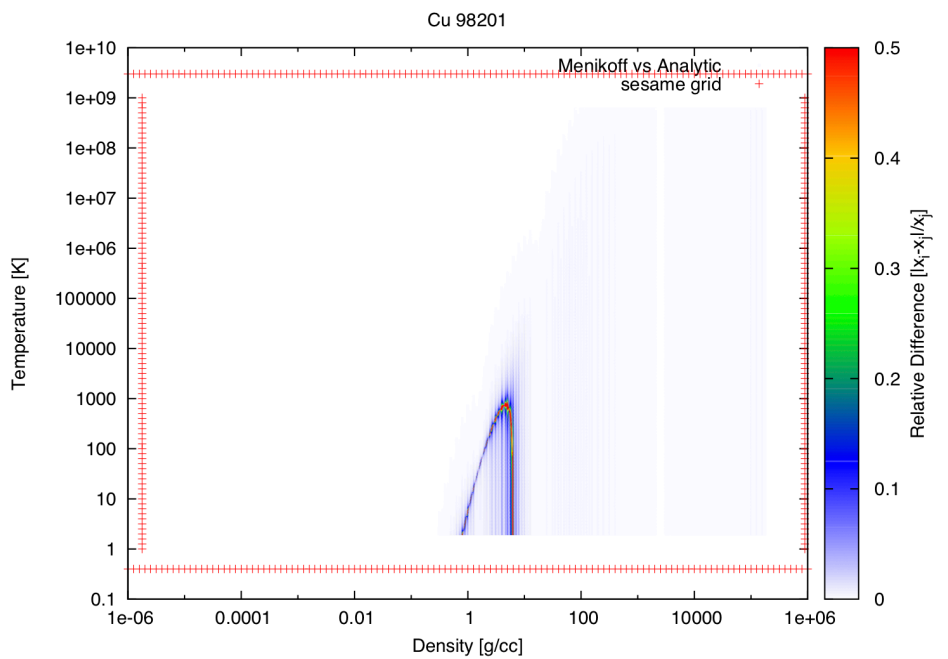


Menikoff

$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_T + \frac{T}{\rho^2 \left(\frac{\partial U}{\partial T} \right)_\rho} \left(\frac{\partial P}{\partial T} \right)_\rho^2$$

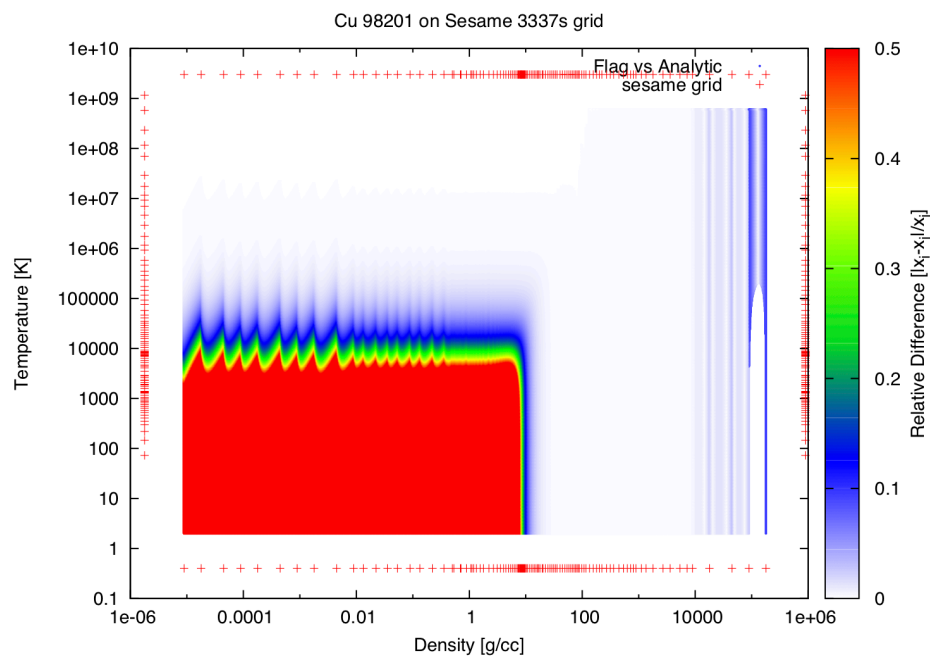


Typical Sesame Grid

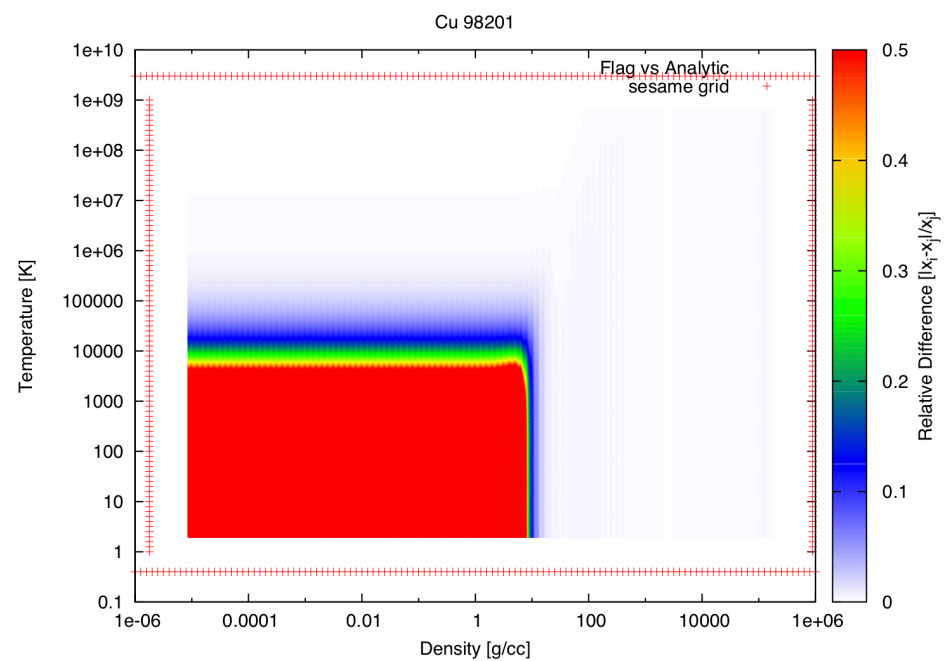


Even log spacing

FLAG
$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_U + \frac{P}{\rho^2} \left(\frac{\partial P}{\partial U} \right)_\rho$$



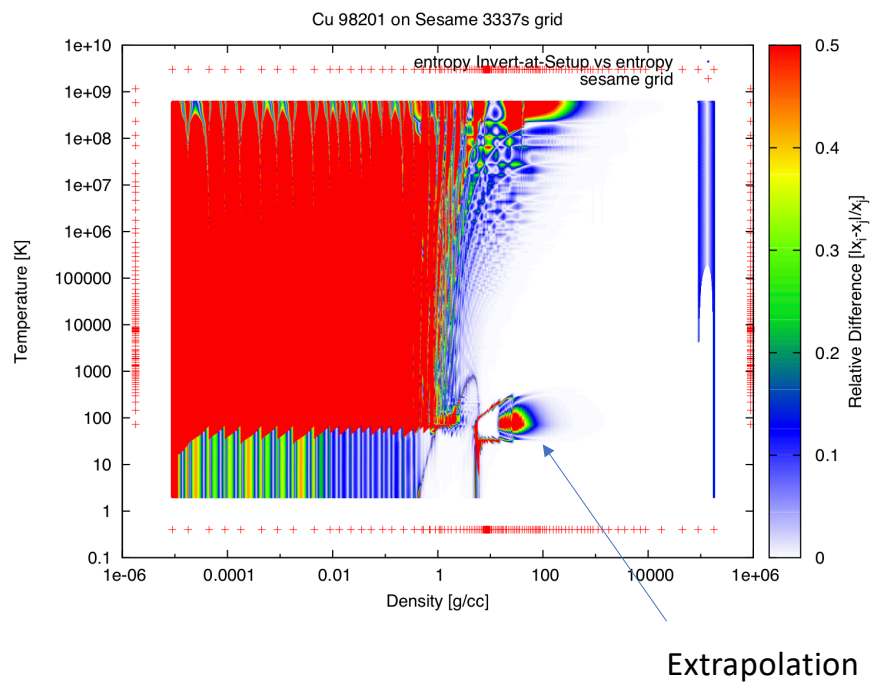
Typical Sesame Grid



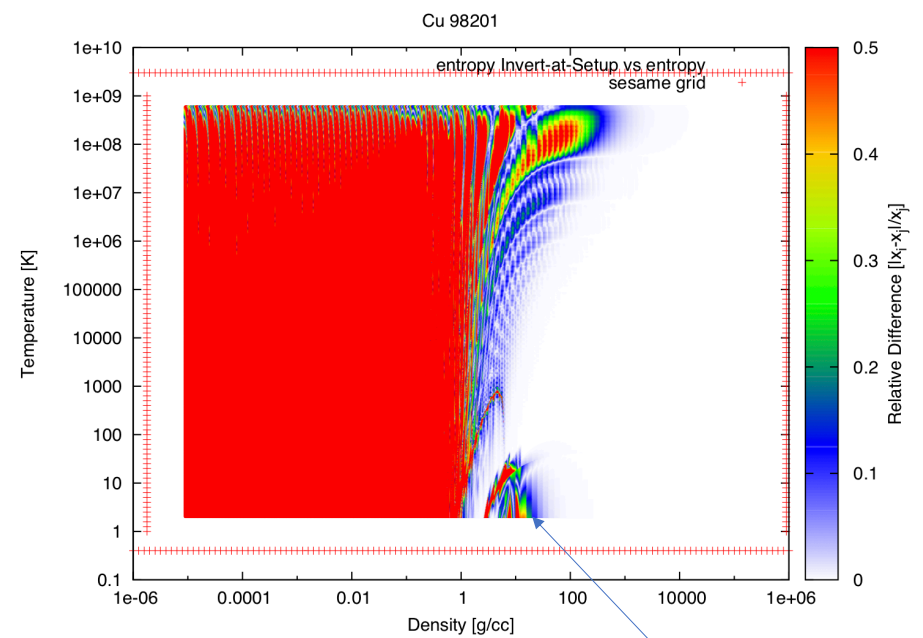
Even log spacing

Entropy1 Invert_At_Setup

$$c^2 = \left(\frac{\partial P}{\partial \rho} \right)_s$$



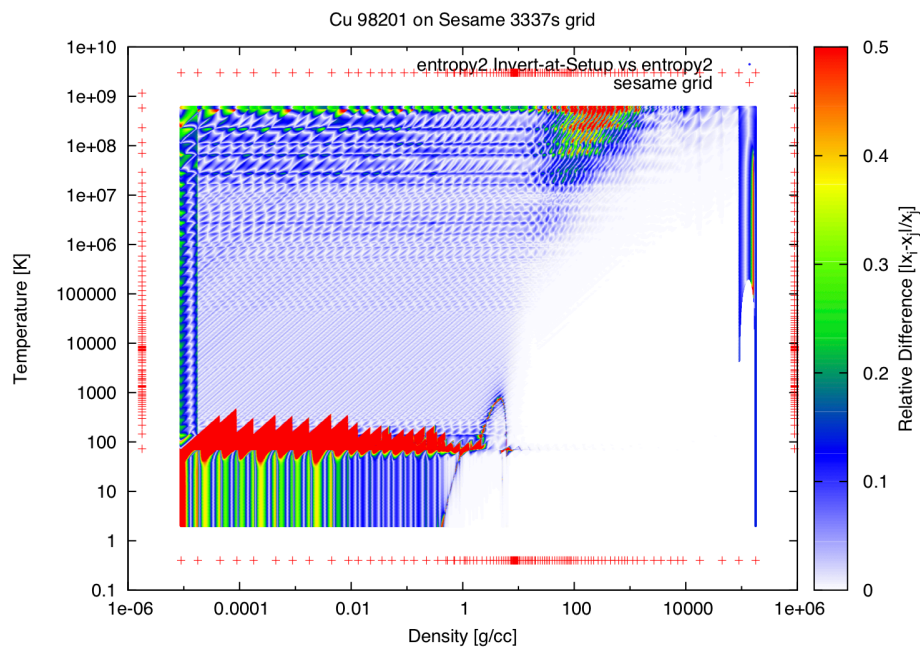
Typical Sesame Grid



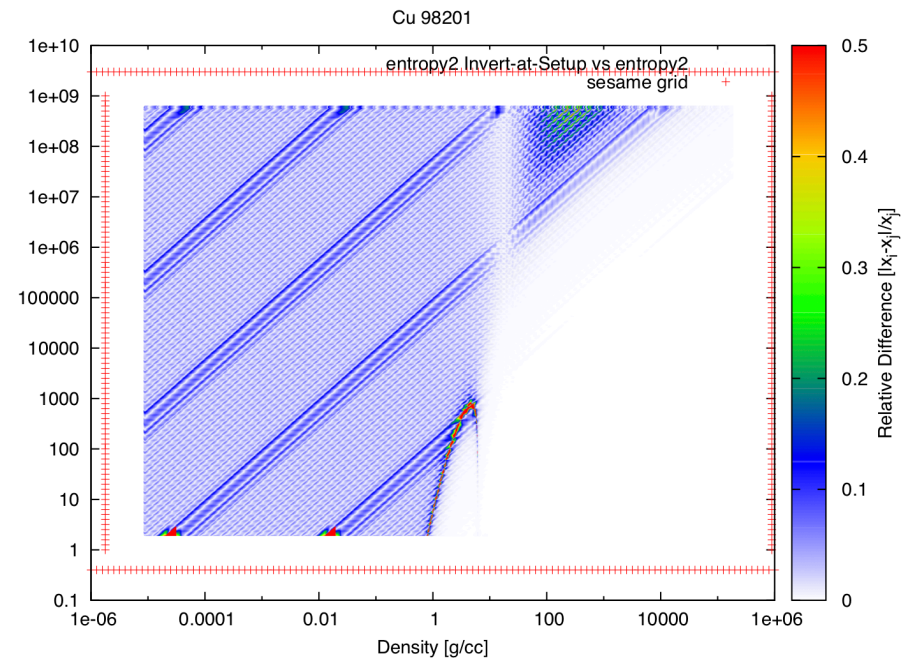
Even log spacing

Entropy2 Invert_At_Setup

$$c^2 = \frac{-\left(\frac{\partial S}{\partial \rho}\right)_P}{\left(\frac{\partial S}{\partial P}\right)_\rho}$$

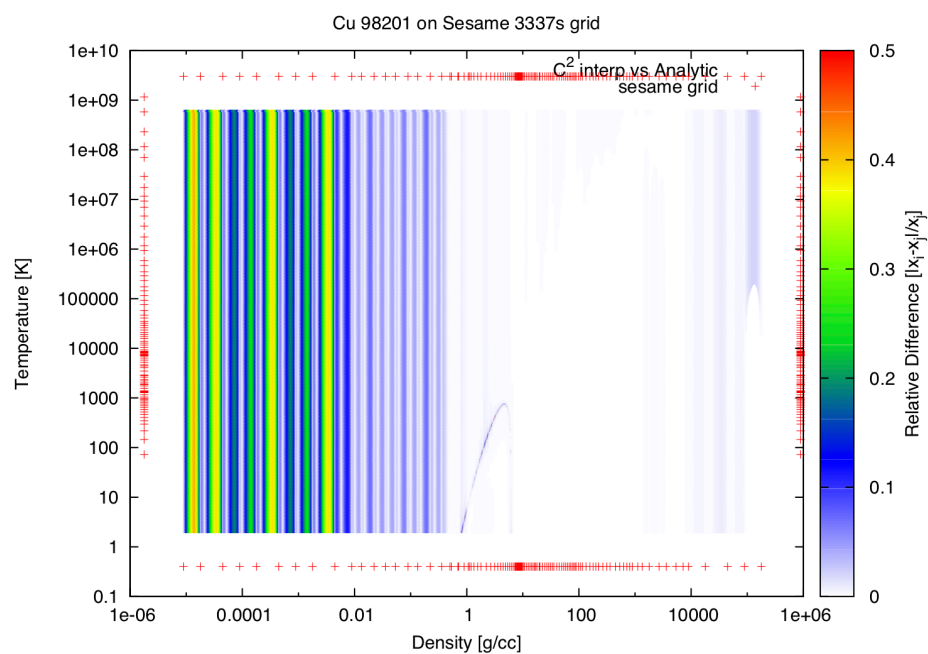


Typical Sesame Grid

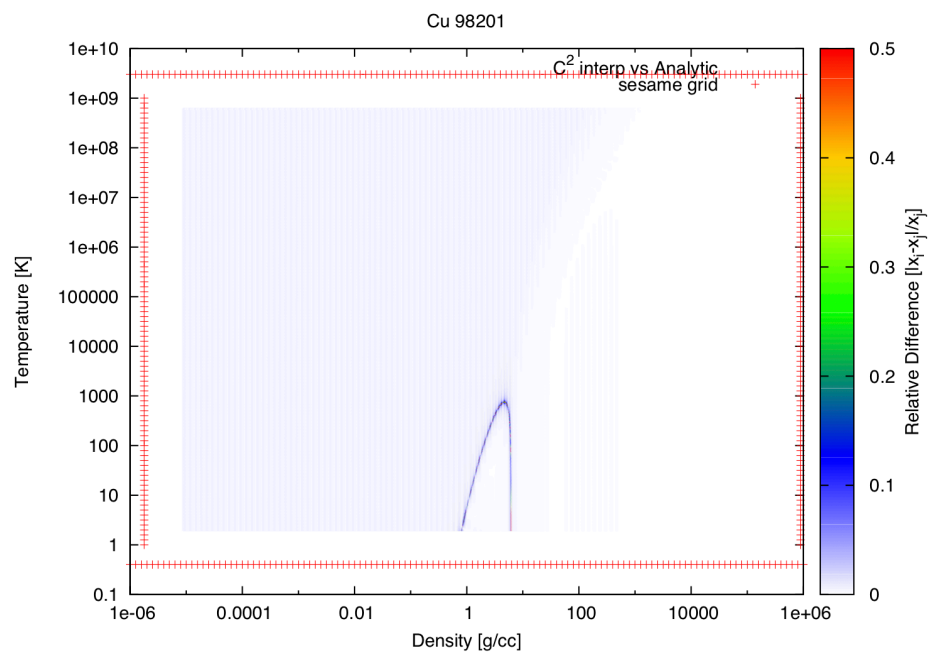


Even log spacing

Direct Tabulation of C^2 in 300 style table

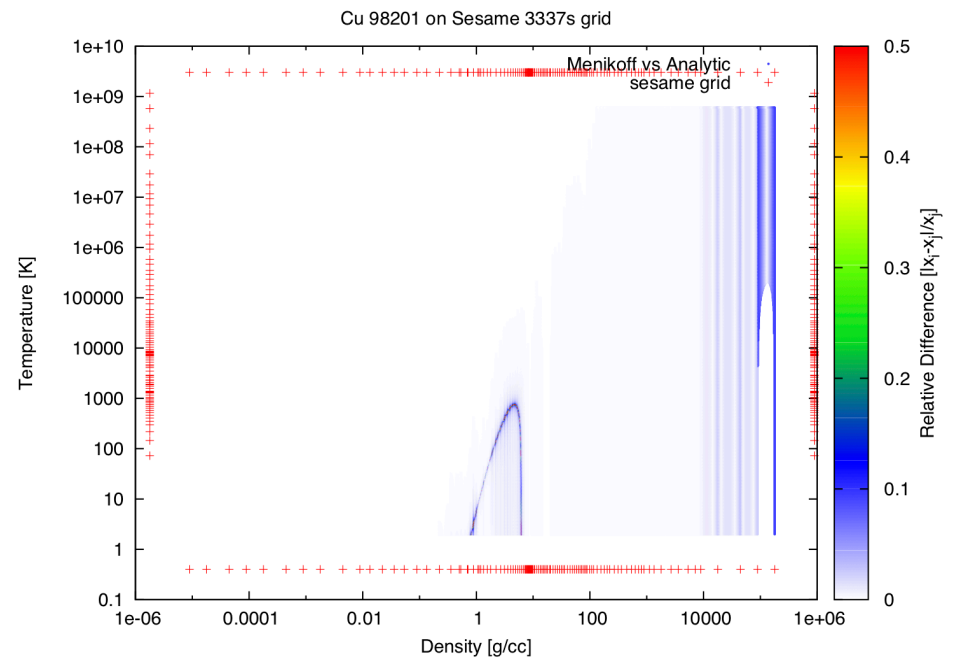
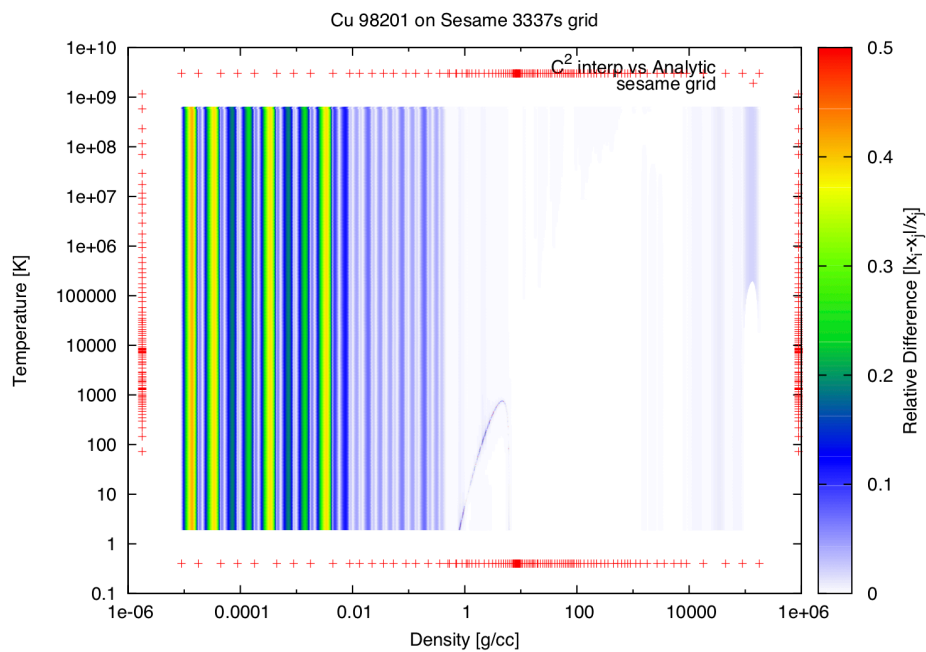


Typical Sesame Grid



Even log spacing

Menikoff vs direct interpolation of C^2



Menikoff vs direct interpolation of C^2

