A DensityDependentnucleon-nucleoninteraction for the HD-EOS

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Punchline

We do not know enough on the nucleon-nucleon (ant three nucleon) interaction to reliably make prediction on the equation of state…

"Standard" Monte Carlo methods : VMC & GFMC

Green's Function Monte Carlo

Project the ground state using the standard proagator:

$$\psi(R,t) = e^{-(H-E_T)t}\psi(R,0)$$

$$\psi(R,t) = \int dR' G(R,R',t)\psi(R',0)$$

Approximate with a finite sum of eigenstates of the position ("walkers")

the propagator can be broken in the usual way using the Trotter-Suzuki formula:

Diffuses the walker

Weights the walker, and produces zero, one or more copies

Auxiliary Field Diffusion Monte Carlo (AFDMC)

Hubbard Stratonovich transform

Appro. order $\Delta\tau$

2 body operators ⇨ $\int$ Auxiliary Field x ✚ 1 body operator

AFDMC = DMC + HS-transform

Other issues:

- Sign problem "treated" with Fixed-Phase approximation.
- Wave functions simplified to a central Jastrow (no operatorial dependence) times an antisymmetrized product of spinors.

[Schmidt &Fantoni, PLB 446, 99 (1999)]

[Fantoni,Sarsa ,Schmidt,Prog.Part.Nuc.Phys. 44 2000)]

[Gandolfi et al, PRL 99,022507, (2007)]

Equation of state of neutron matter at high density

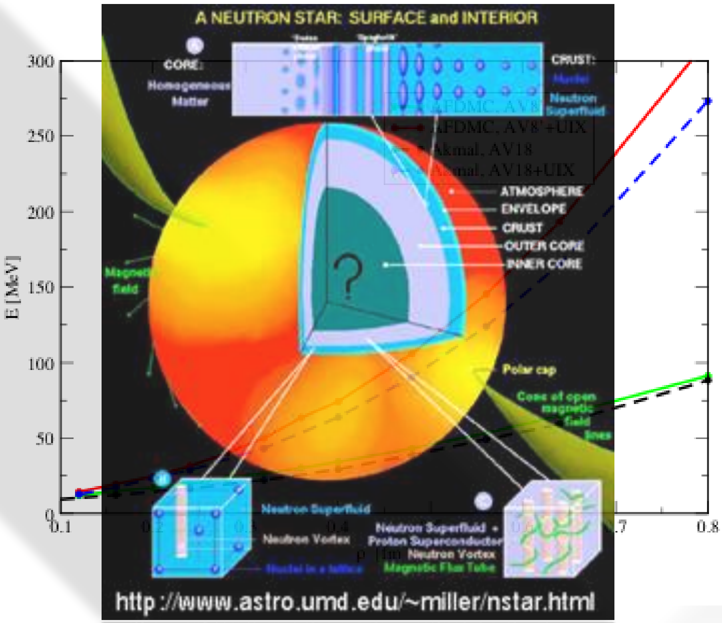
We revised the computations made on Neutron Matter to check the effect of the use of the fixed-phase approximation.

Results are *more stable*, and some of the issues that were not cleared in the previous AFDMC work are now under control.

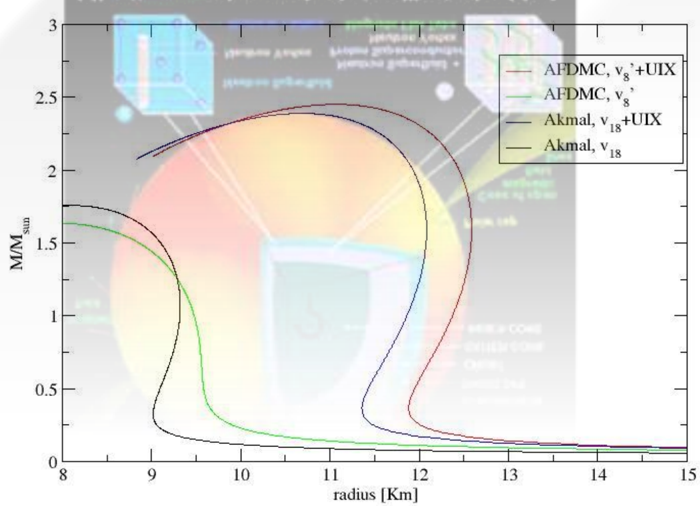
In particular the *energy per nucleon* computed with the AV8' potential in PNM with A=14 neutrons in a periodic box is now *17.586(6)MeV*, which compares very well with the GFMC-UC calculations of J. Carlson et al. which give *17.00(27)MeV*. The previous published AFDMC result was *20.32(6)MeV*.

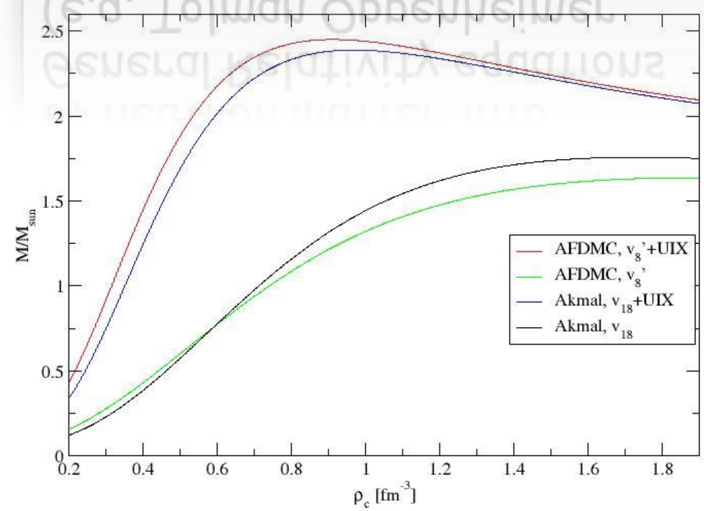
The functions in the Jastrowfactor are takenas the scalar componentsof the FHNC/SOC correlationoperatorwhichminimizes the energy per particleof SNM at saturation density r_0=0.16 fm^{-1}. The antisymmetricproduct *A* is a Slaterdeterminantof *planewaves*.

Equation of state of neutron matter



Plugging the equation of state of neutron matter into General Relativity equations (e.g. Tolman Oppenheimer Volkov equation), it is possible to make predictions about the structure of compact stars!





Density dependent potential

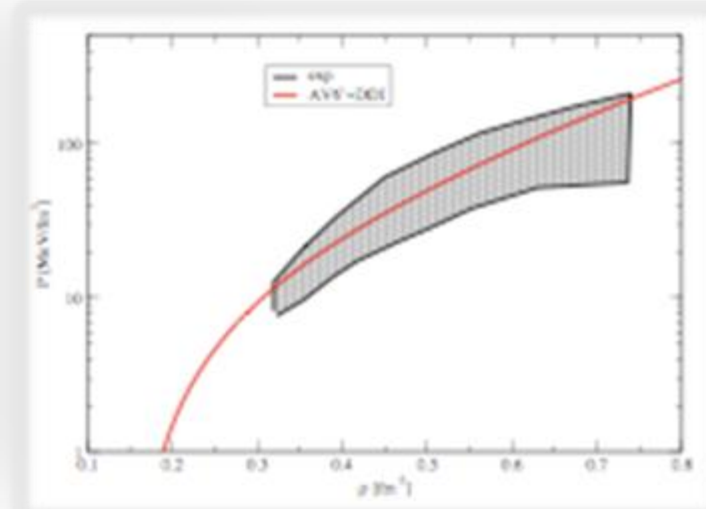
Following Lagaris and Pandharipande *(Nucl. Phys. A359, 349 (1981)),* it is possib;e to redifine the interaction with density dependent parameters:

The density dependent repulsive part is a modification of the intermediate part of AV6':

The attractive part is completely phenomenological, and it is written as:

Density dependent potential

The parameters are fitted in order to reproduce the saturation density, the energy at the saturation density and the compressiblity of symmetric nuclear matter. The values are



The equation of state of nuclear matter fitted with these values of the parameters is:

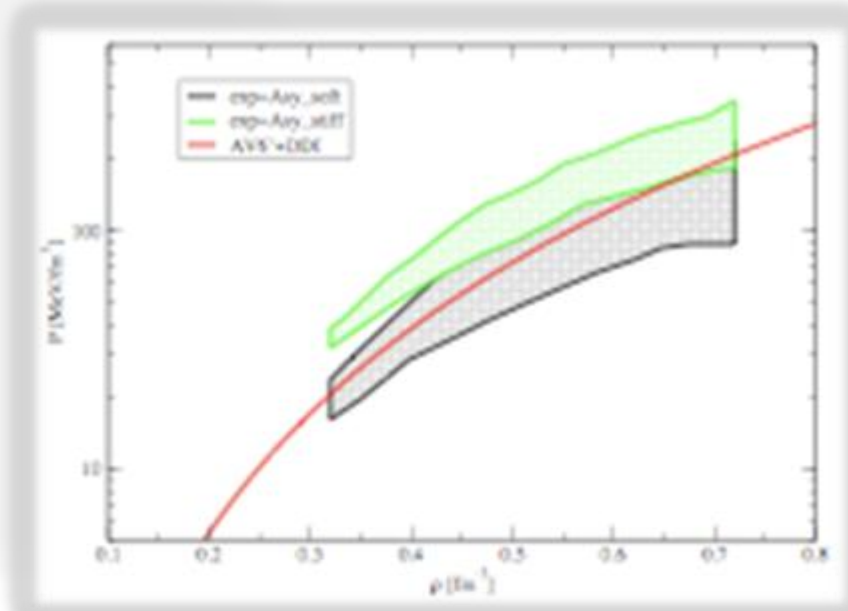
with:

Density dependent potential

Using the *same parameters in the Hamiltonian*, we computed the equation of state of pure neutron matter. The results are strikingly good.

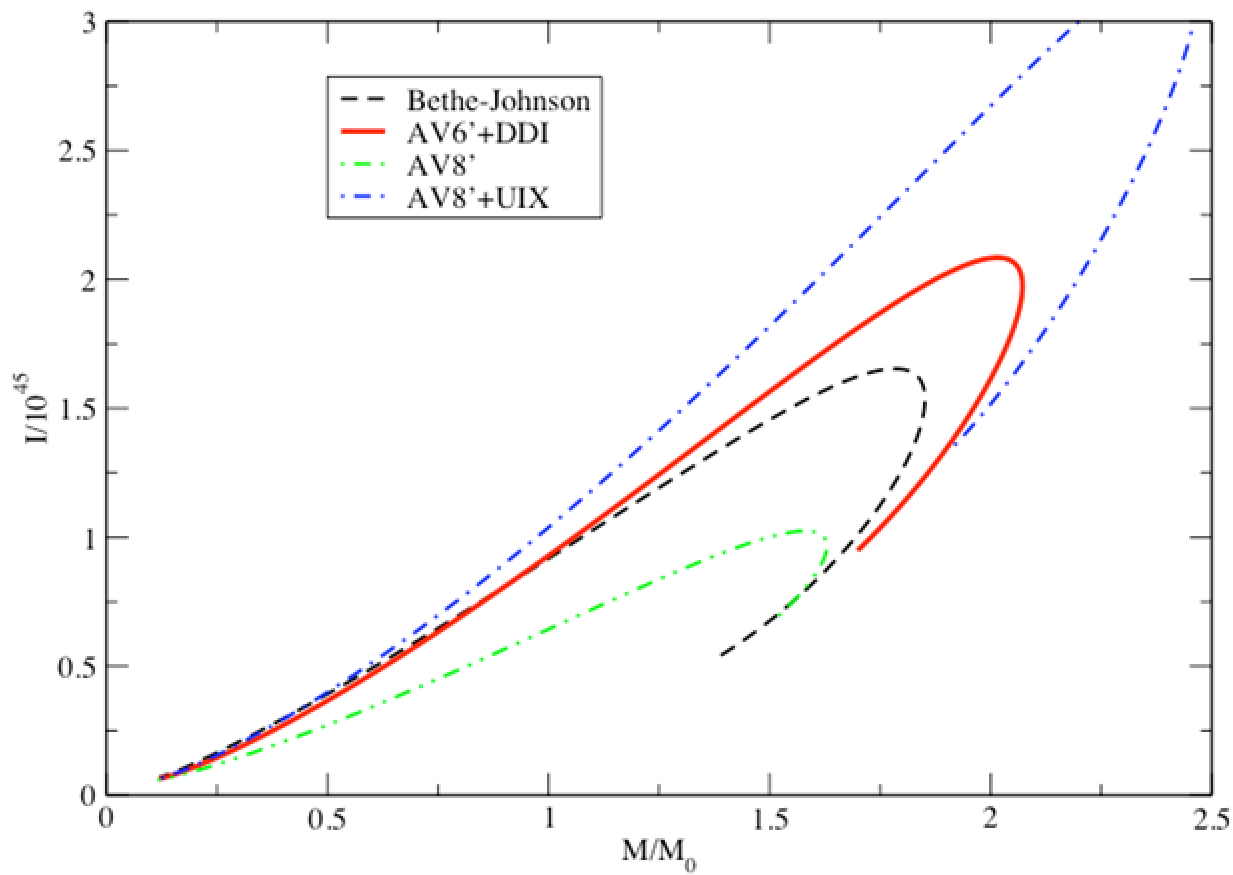
In this case the equation of state is fitted with the expression:

with:



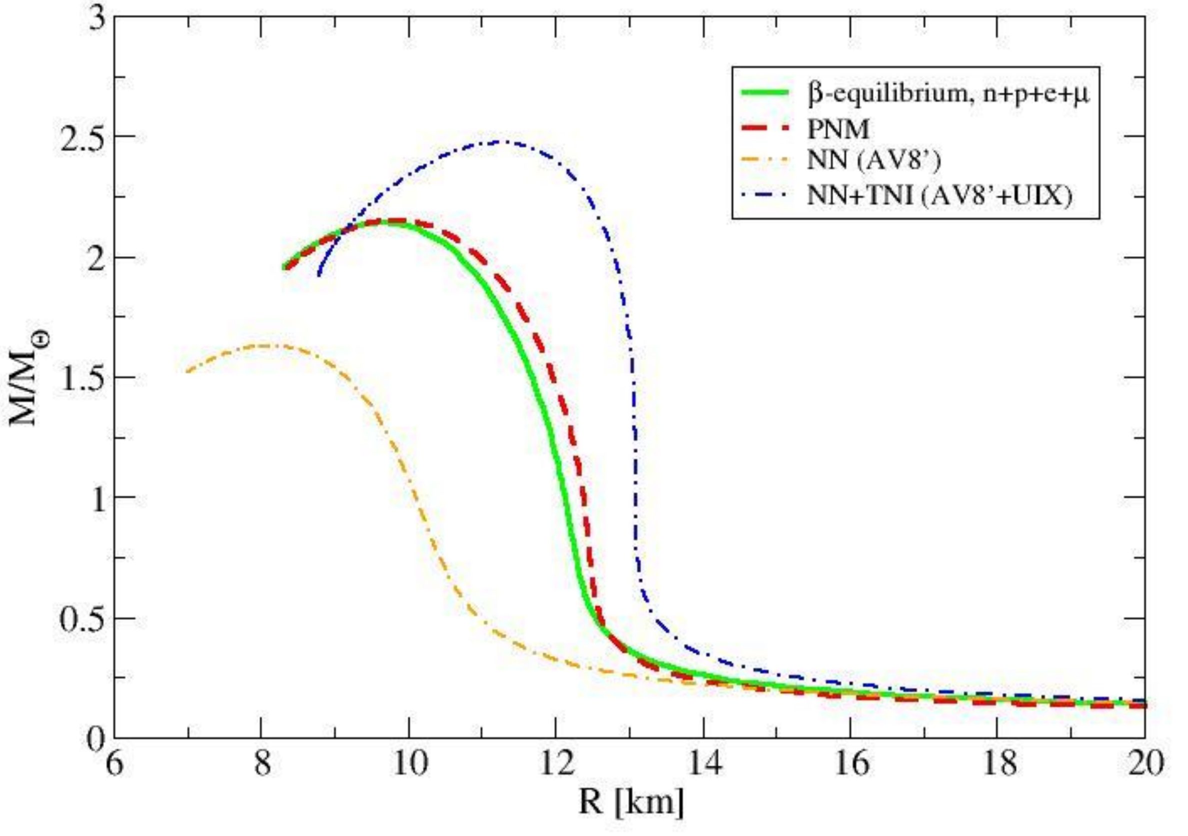
Density dependent potential

Momentum of inertia vs. mass of the star



Density dependent potential

Mass vs. radius of the star



Density dependent potential