What is the Impact of cold atom EOS on NS matter ?

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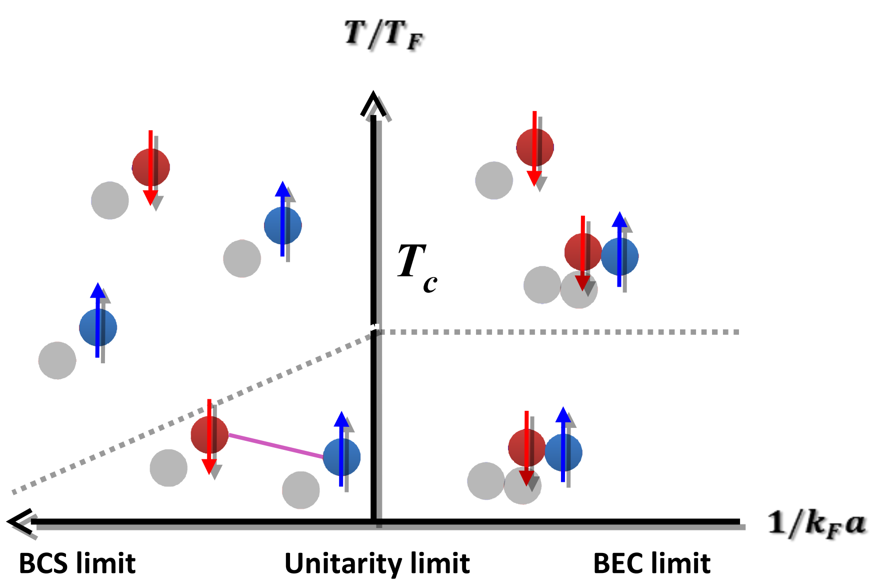
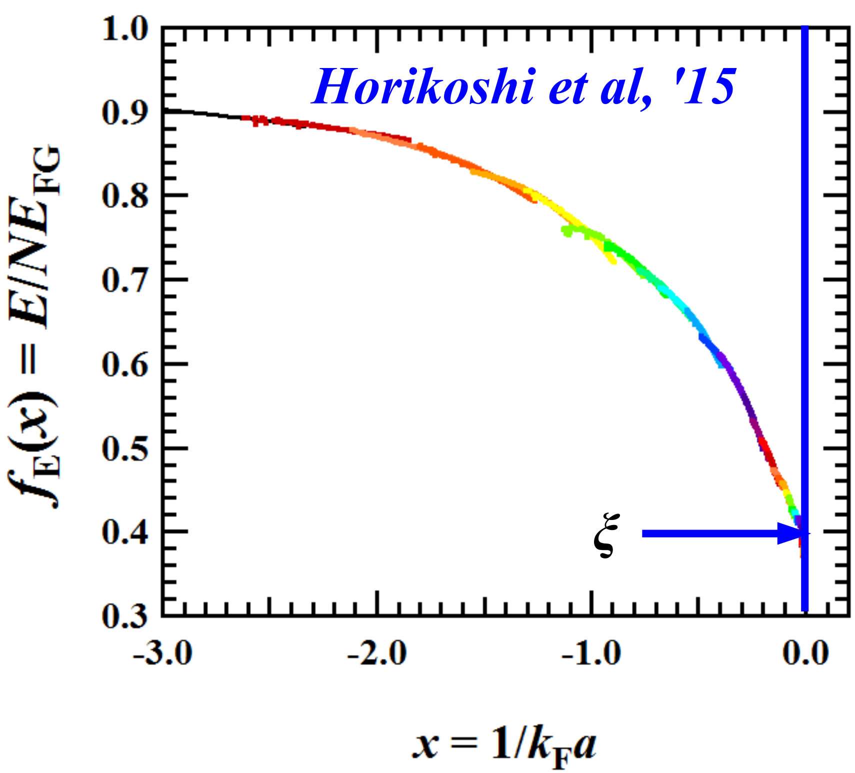
- **Neutron drip (~ 4 x 10^{11} g/cc)**
  - **Neutron Rich Nuclei + Neutron Gas**
  - **Neutron matter ~ Unitary gas**
    Quantum simulation by cold atoms
- **Cold atom EOS ($x=1/k_F a_0 \neq 0$) is measured !**
  (Horikoshi et al., in prep.)

Cold Atom EOS

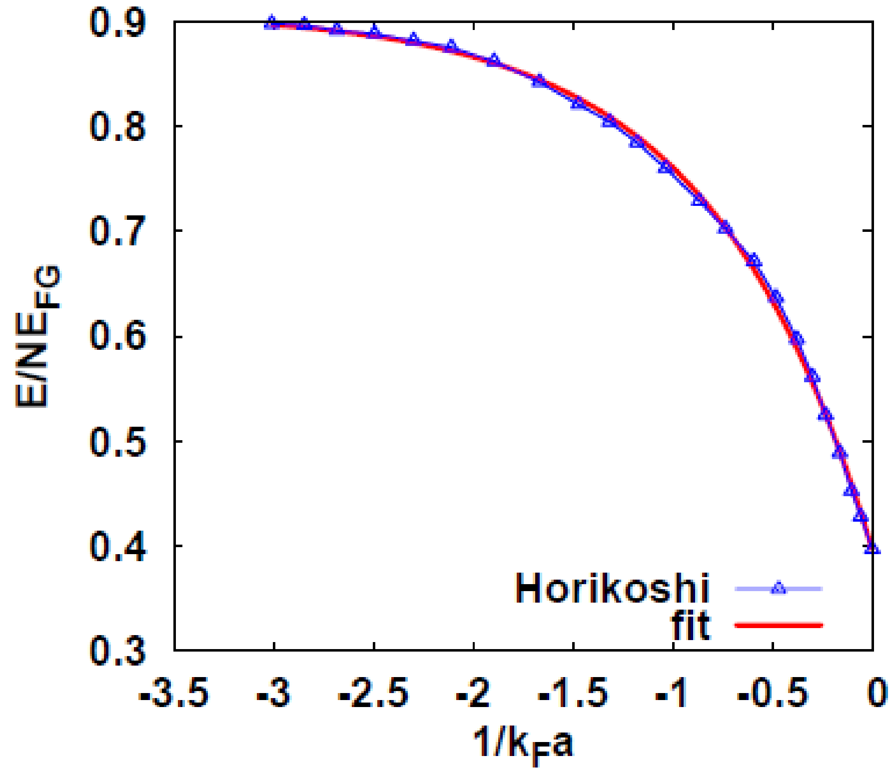
- $E=\xi E_{FG}$ ($\xi \sim 0.4$) in the unitary limit ($1/k_F a_0 \to 0$, $k_F r_{eff}=0$)
  - ξ: Bertsch parameter (INT workshop)
- EOS measurement off unitary limit
  Horikoshi et al., 2015
- How can we use the cold atom EOS in the context of NS matter ?

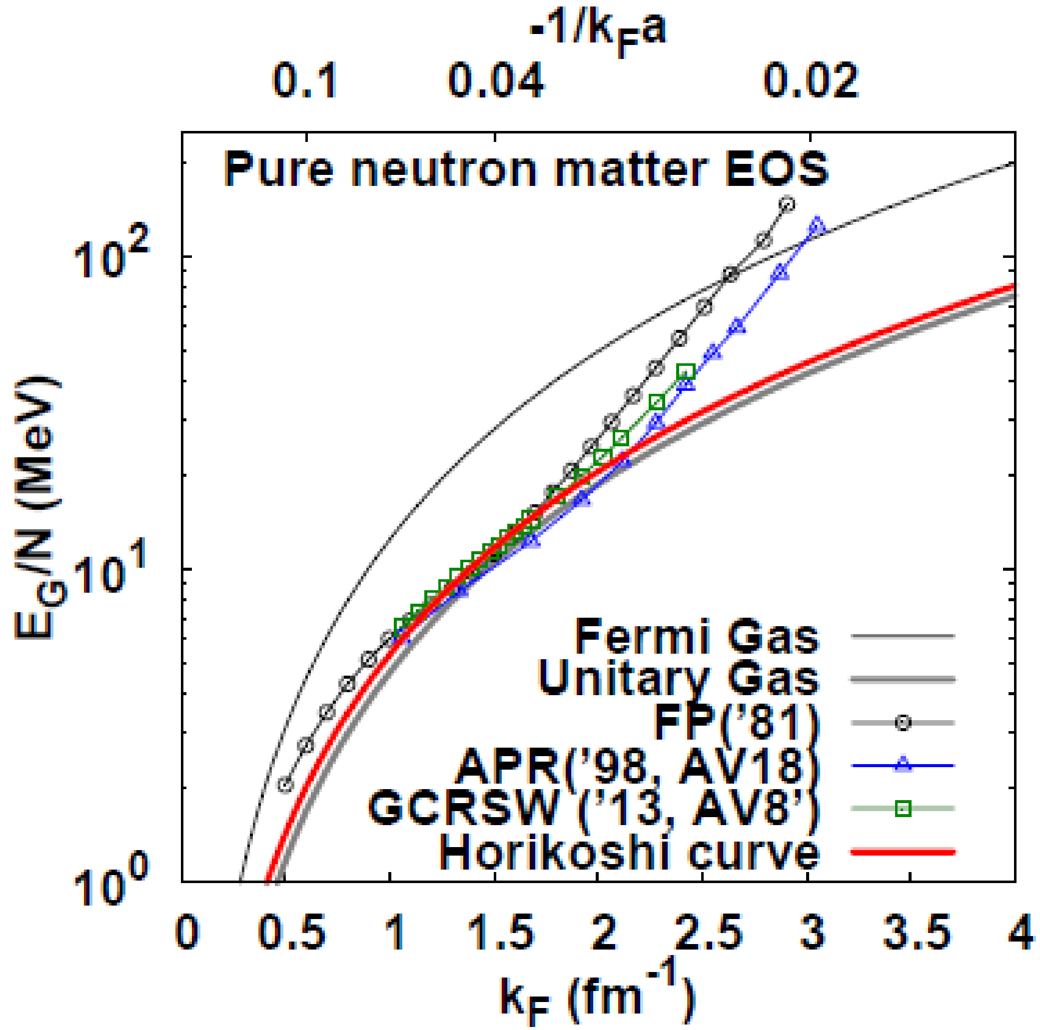




Comparison with Pure Neutron Matter EOS

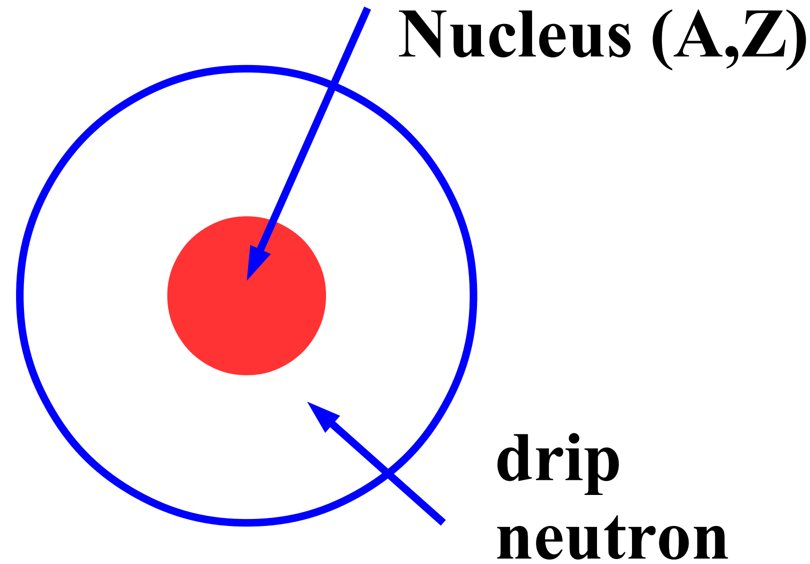
- Cold Atom EOS is consistent with MC result.
- How can we evaluate the effective range correction ?
- Does it have other impacts in neutron star physics ?





Low Density Neutron Star Matter EOS

- Nuclei & electron ($\rho < 4 \times 10^{11}$ g/cc)
- Nuclei, drip neutron, electron
  (4×10^{11} g/cc $< \rho < 2.5 \times 10^{14}$ g/cc)
  → pure neutron matter EOS
- Uniform nuclear matter
  ($\rho > 2.5 \times 10^{14}$ g/cc)
  → nuclear matter EOS at Z << N

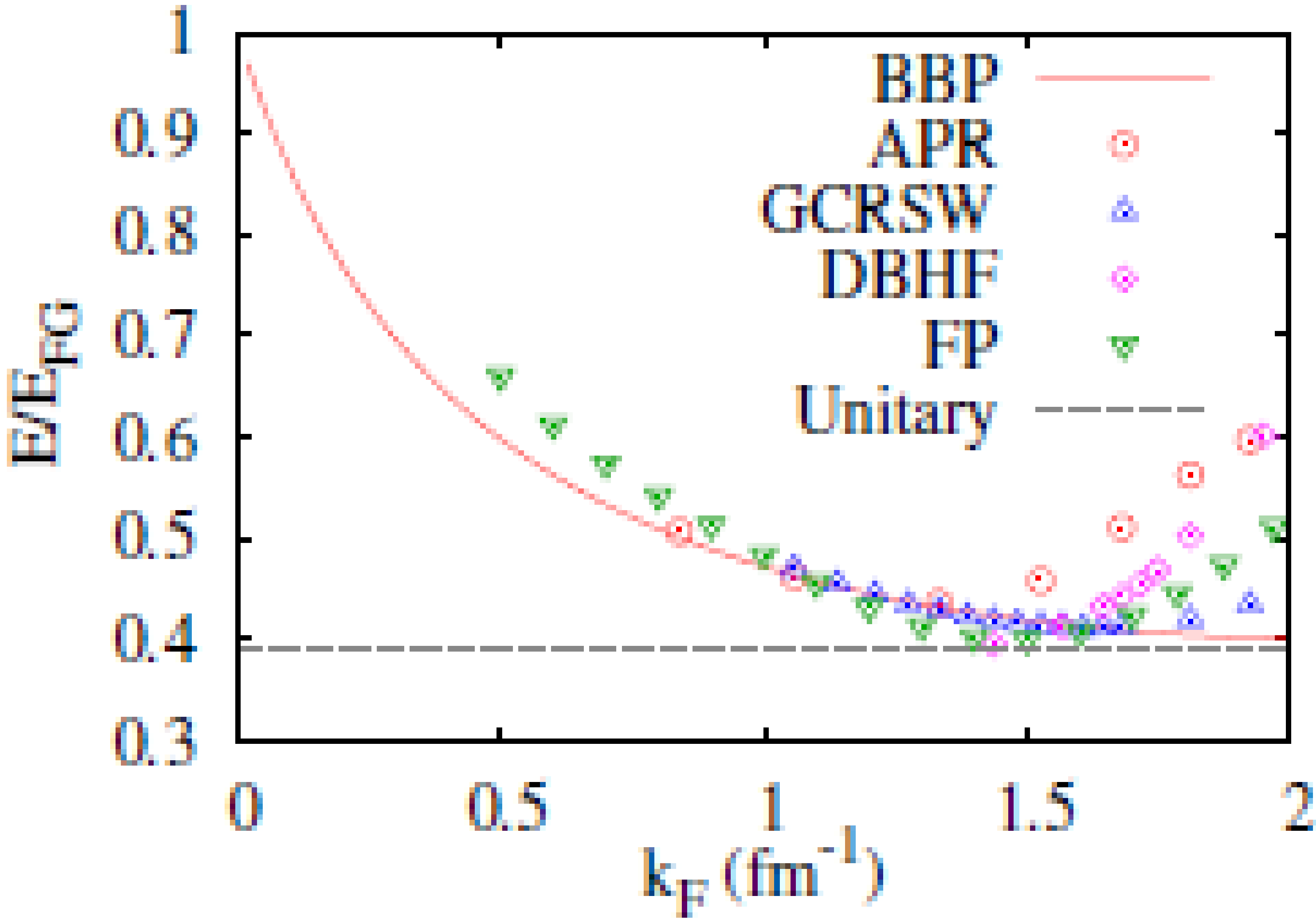


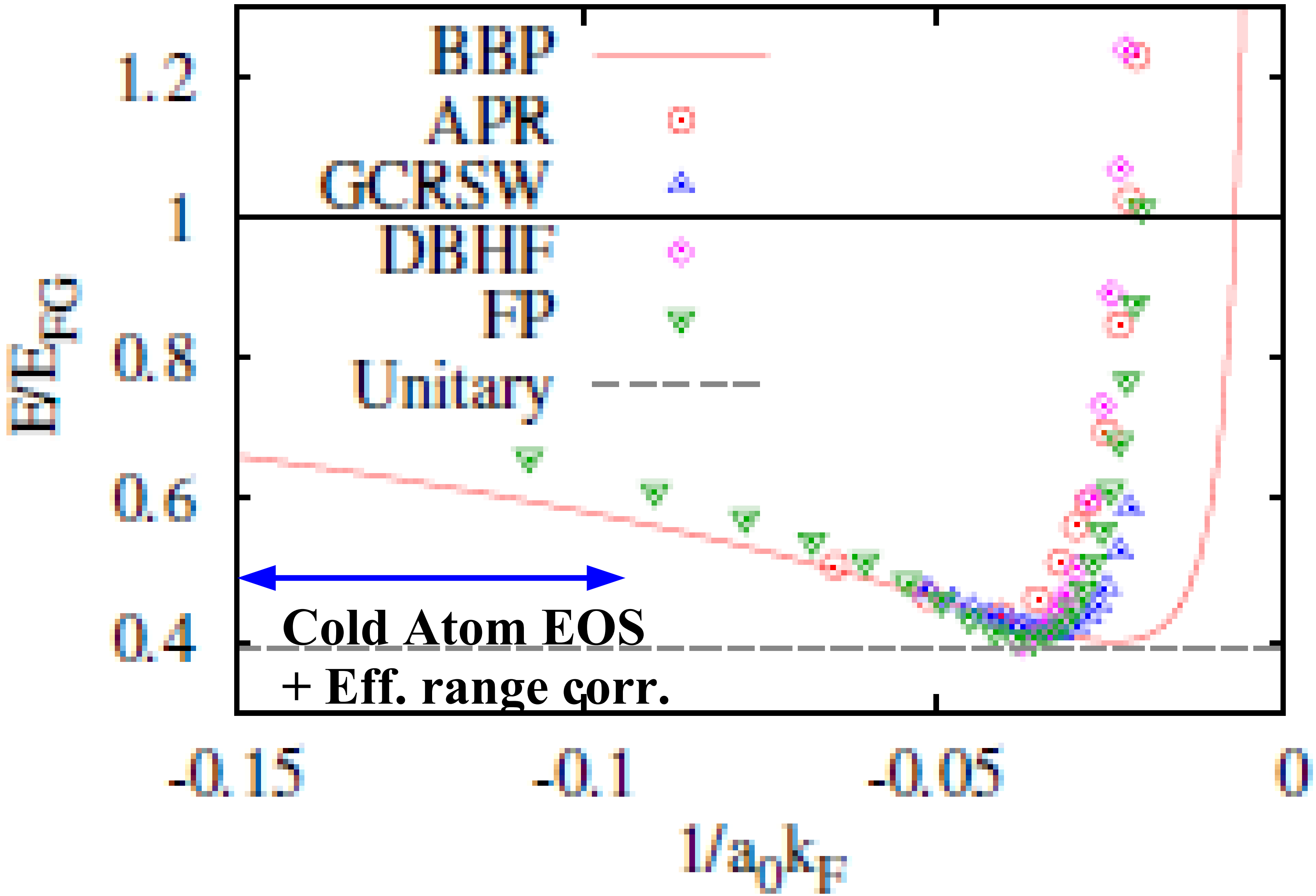
- "Standard" (low density) NS matter EOS
  G. Baym, H.A. Bethe, C. J. Pethick, NPA175('71),225.
  Bulk pure neutron matter EOS

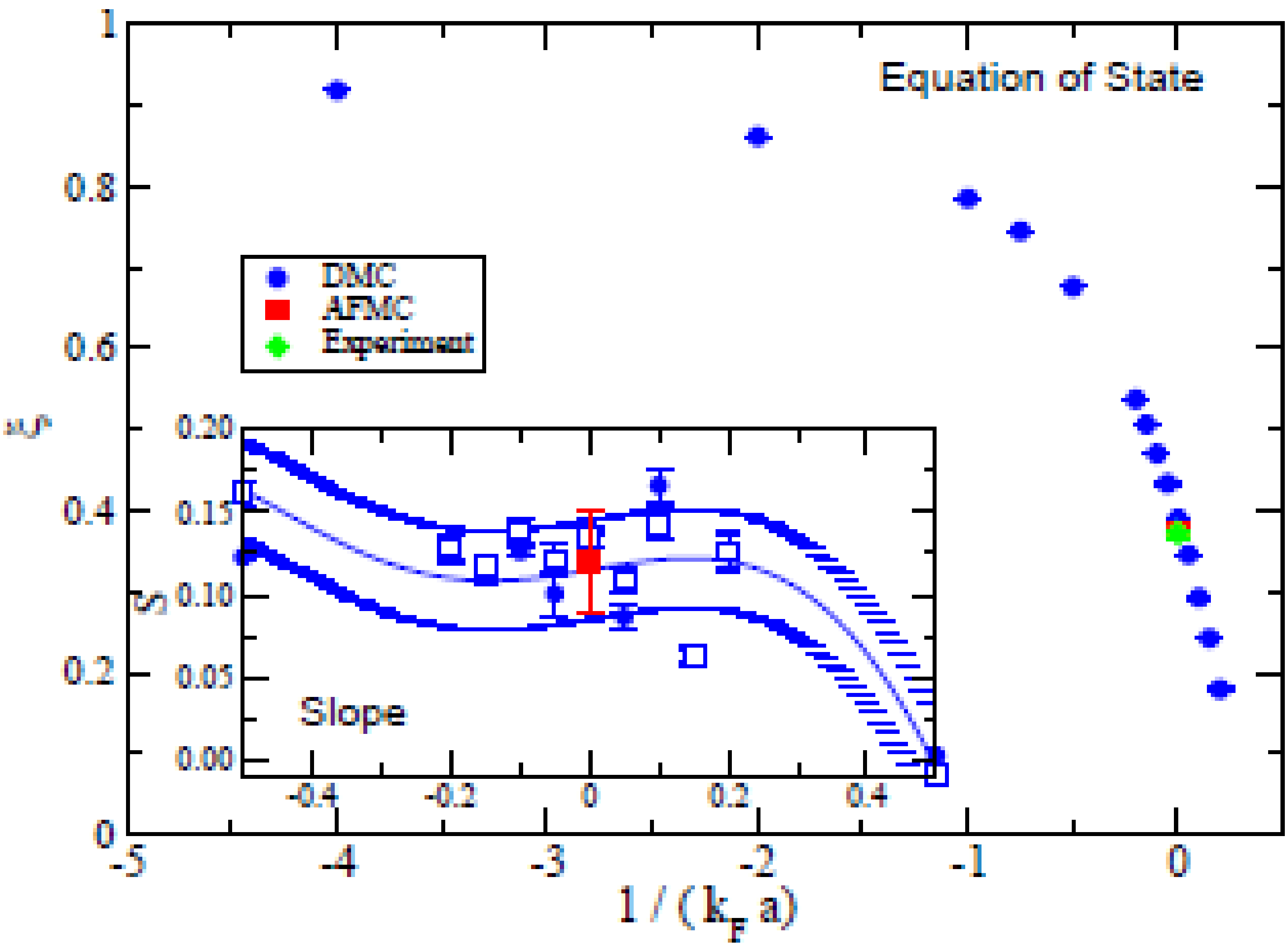
$$W(k,0) \approx \underbrace{19.74k^2}_{\text{kin. E}} - k^3 \frac{(40.4 - 1.088k^3)}{(1 + 2.545k)}$$

Fermi mom.

$\propto \rho$


BBP
APR
GCRSW
DBHF
FP
Unitary
E/E_FG
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.5
1
1.5
2
k_F (fm^-1)


BBP
APR
GCRSW
DBHF
FP
Unitary
1.2
1
0.8
0.6
0.4
E/E_FG
-0.15
-0.1
-0.05
0
1/a_0k_F
Cold Atom EOS
+ Eff. range corr.


Equation of State
DMC
AFMC
Experiment
Slope
1 / (k_F a)