Lattice QMC simulations of nuclear many-body systems

1. Equation of state of pure neutron matter

- Mass-radius relationship and maximum neutron star mass
- Neutron star tidal deformability: late inspiral phase of compact star mergers
- Interpretation of observable gravitational waveforms (coming from e.g. Advanced LIGO)

2. Neutron-rich nuclei

- Nuclear masses essential input for r-process nucleosynthesis simulations
- Interface with future radioactive beam facilities, e.g. FRIB

Recent progress

Chiral effective field theory + QMC

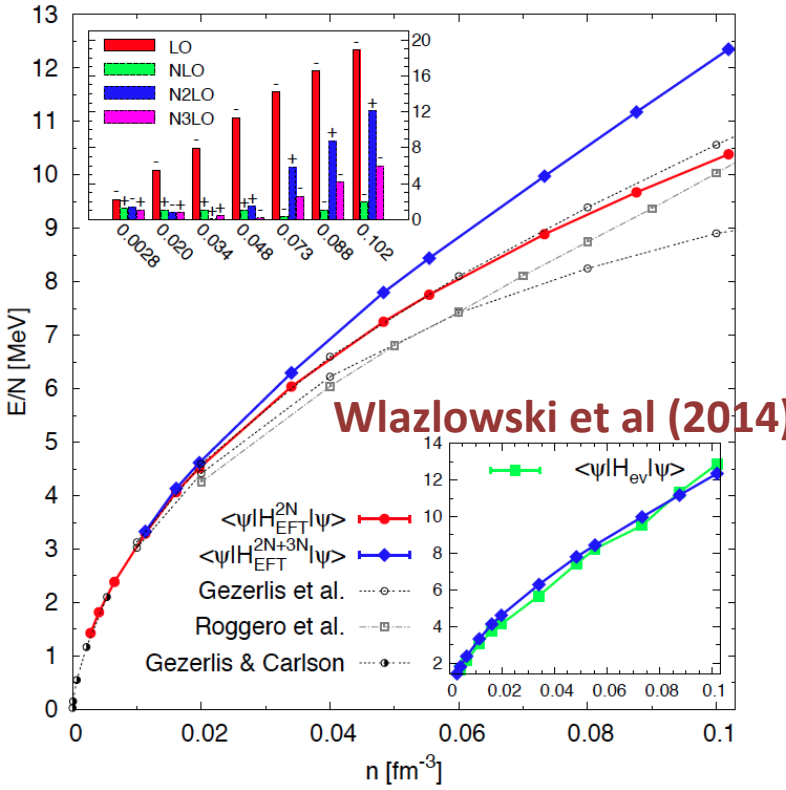
- *Realistic microphysics:* multi-pion exchange, Pauli blocking, many-body forces
- *Uncertainty estimates:* variations in cutoff scale

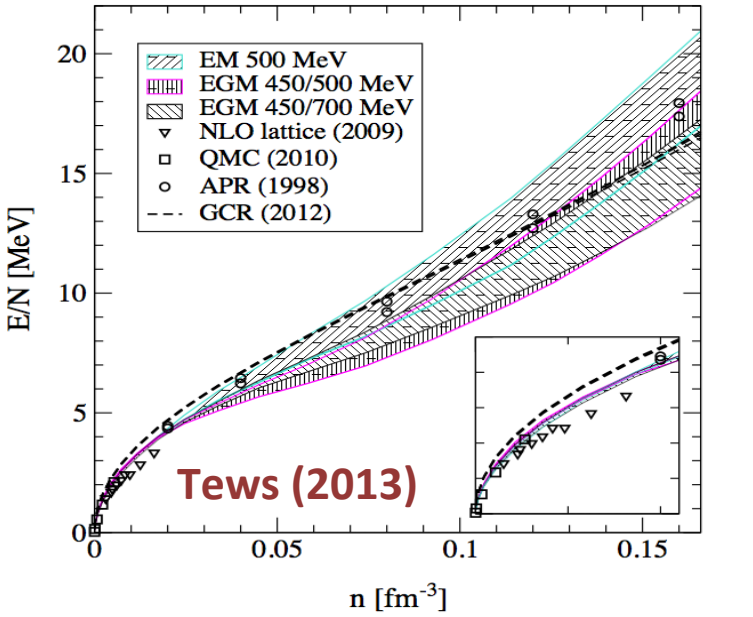
- Agreement among many different QMC groups

First calculations of **N3LO three- and four-body forces** (only in Hartree-Fock approximation)

Lattice methods: facilitate implementation of nuclear many-body forces (derived in plane-wave basis)

The newly developed lattice QMC approach (Wlazłowski et al., 2014) is free of the fermion sign problem for pure neutron systems and N=Z even-even nuclei.





Challenges

Neutron matter EoS at high density

- Can we make reliable predictions beyond nuclear matter saturation density?
- N3LO three- and four-nucleon forces beyond Hartree-Fock approximation
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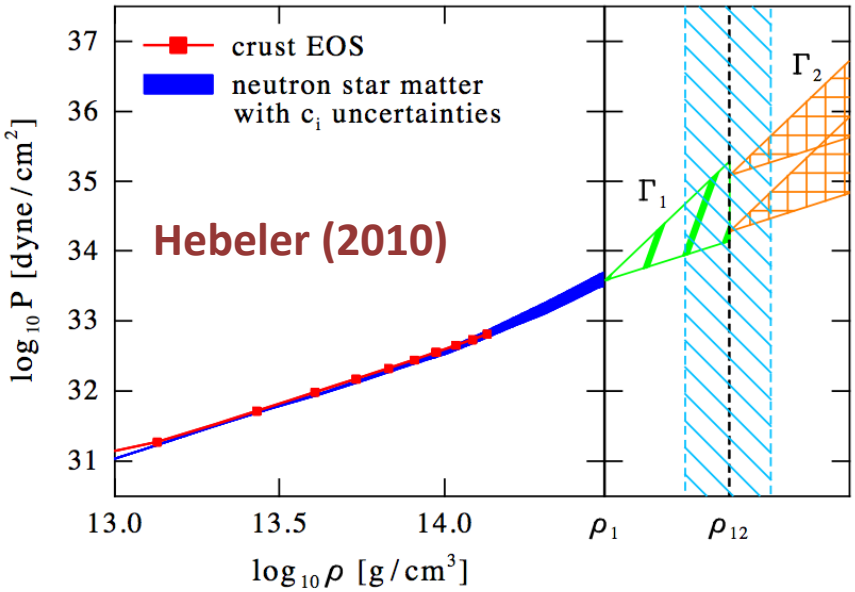

Medium-mass and heavy nuclei

- **Current implementations:** limited to light nuclei
- **Compute heavier nuclei using the new lattice QMC method free of the sign problem for even-even N=Z nuclei**