Pionless effective field theory for A=3,4

Leading-order 2-body interactions lead to divergence in A=3
(in the triton channel), cutoff dependence generates "Phillips line"
see, e.g., P.F. Bedaque and U. van Kolck, Annu. Rev. Nucl. Part. Sci. **52**, 339 (2002).

and band around "Tjon line" of alpha particle (^{4}He) vs. triton (t) energies
L. Platter, H.-W. Hammer and U.-G. Meissner, Phys. Lett. B **607**, 254 (2005).

points are results based on different NN potential models
correlate along a line/band: "Phillips line" and "Tjon line"

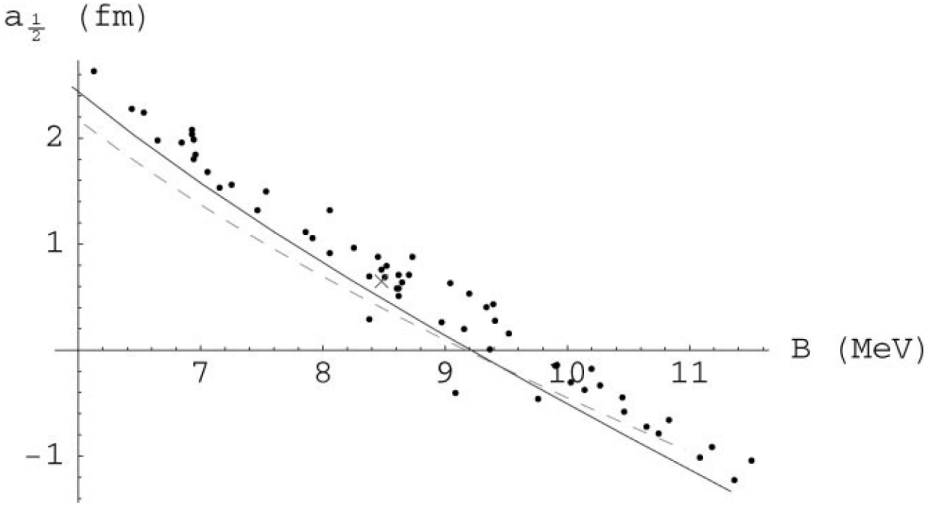
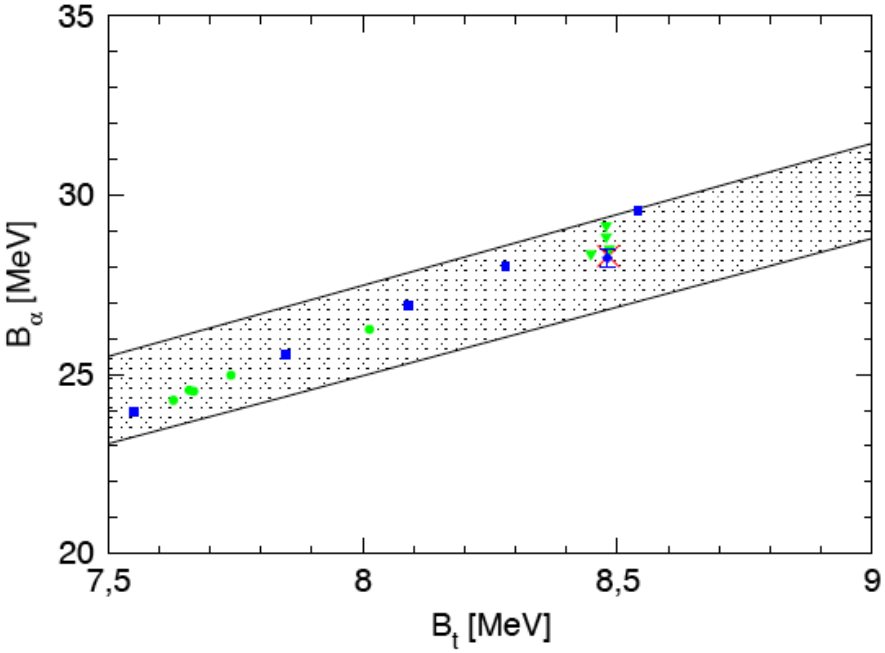


Figure 9 Correlation between the doublet *S*-wave nucleon-deuteron scattering length and the triton binding energy (Phillips line): predictions of different models (points), EFT at LO (light dashed line) and NLO (dark solid line), and experimental value (cross).



This universal correlation follows from EFT without 3-body interactions.

Running 3-body coupling

Leading-order 3-body interaction ~H(Λ) in the triton channel matched to triton binding energy (or S-wave N-d scattering length) exhibits a periodic running: "limit cycle" - compare to running of $C_0(\Lambda)$

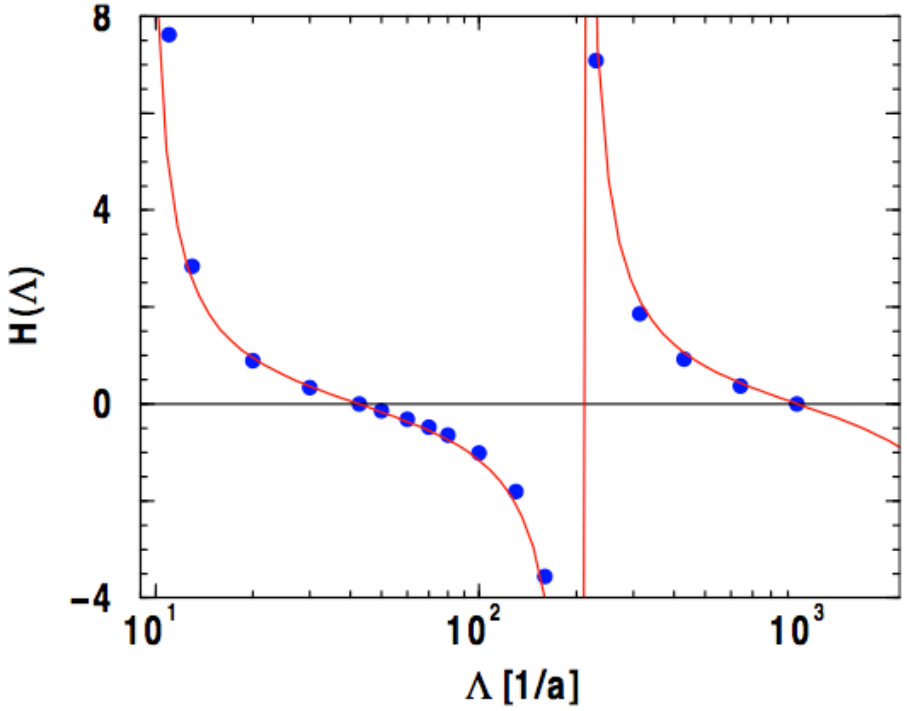


Figure 5: The three-body coupling H as a function of the cutoff Λ for a fixed value of the three-body parameter Λ_*. The solid line shows the analytical expression (41), while the dots show results from the numerical solution of Eq. (39).

This limit cycle leads to discrete scale invariance in few-body systems with large pairwise scattering lengths.

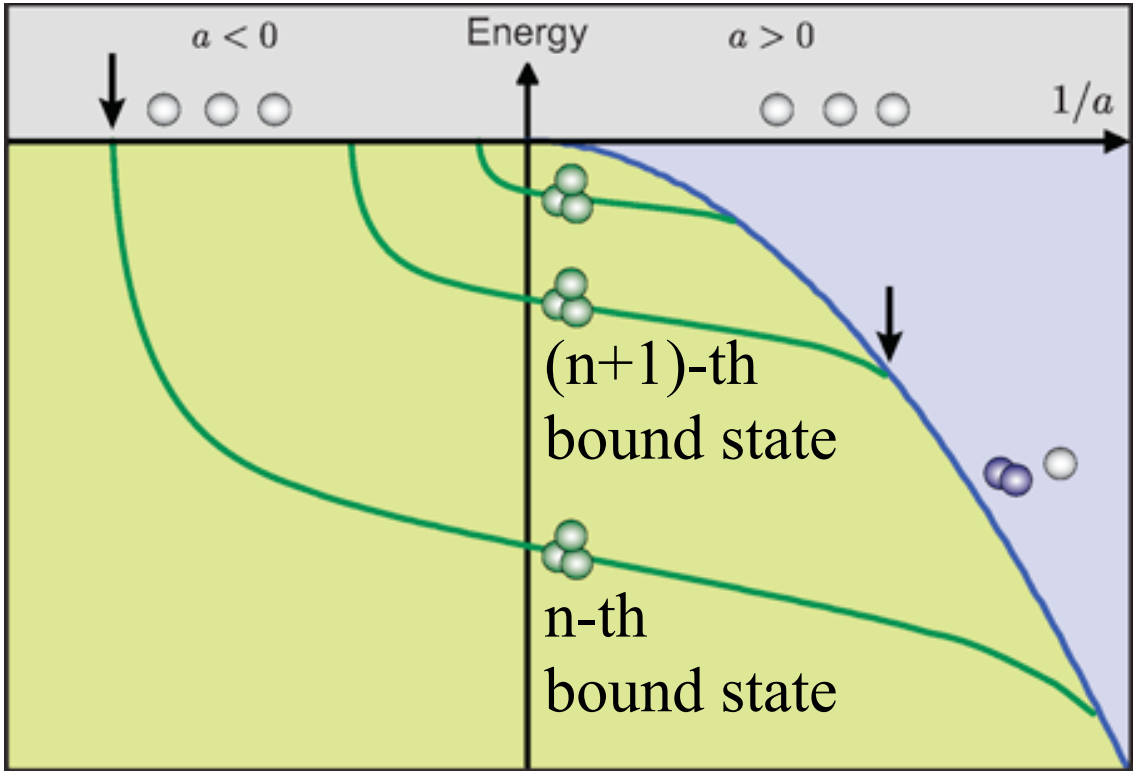
Universal 3-body physics

Efimov effect, nuclear theory prediction by V. Efimov in 1970:

Universal spectrum of 3-body states

reviewed in Ferlaino, Grimm, http://physics.aps.org/articles/v3/9

follows from leading-order interactions
with large pairwise scattering lengths

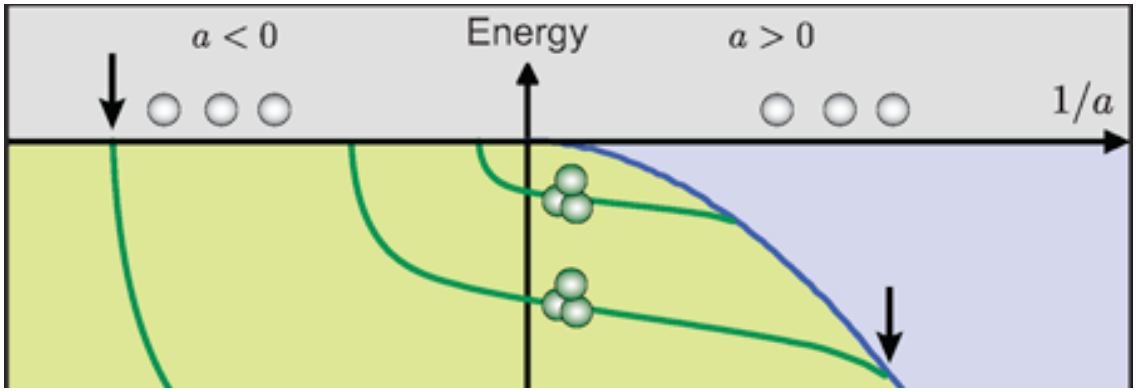


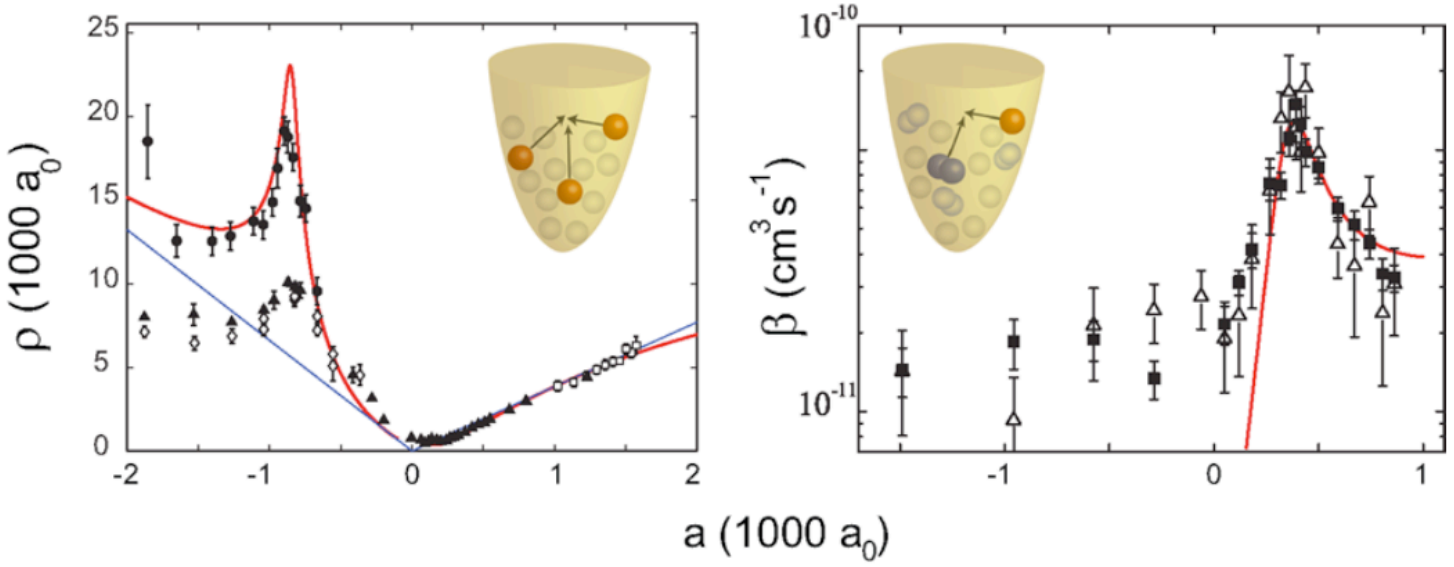
Universal 3-body physics

Universal spectrum of 3-body states

observation of Efimov resonances in trapped ultracold Cs atoms (bosons)

T. Kraemer et al., Nature **440**, 315 (2006), S. Knoop et al., Nature Phys. **5**, 227 (2009).





resonances in 3-body recombination and atom-molecule scattering

Borromean states in nuclei

Universal spectrum predicts "Borromean" sates:
3-body bound states, when all 2-body subsystems are unbound
"Borromean rings"

two-neutron halos: ^{4}He+n+n, ^{9}Li+n+n,… in light neutron-rich nuclei
only known examples of Borromean states in nature