SYEP 2: Symposium Efimov Physics II

Time: Monday 14:30–16:30 Location: C/gHS

Invited Talk SYEP 2.1 Mon 14:30 C/gHS

Efimov Physics from Quantum Field Theory — •Eric Braaten — Ohio State University, Columbus, USA

The quantum-field-theory formulation of the problem of identical bosons interacting through a large scattering length provides deep insights into Efimov physics. In this approach, the zero-range limit is taken exactly, and the consequent short-distance singularities are dealt with using renormalization. The renormalization is governed by an ultraviolet limit cycle, which is reflected in low-energy physics through a 3-body parameter upon which physical observables can only depend log-periodically. In few-body physics, this feature can be exploited to obtain remarkable analytic results for some 3-body observables. One implication for many-body physics is that the momentum distribution approaches its asymptotic form C/k^4 at large momentum k though a subleading D(k)/k^5 term with a log-periodic coefficient. This effect may have been observed in recent experiments on the unitary Bose gas.

Invited Talk SYEP 2.2 Mon 15:00 C/gHS

Efimov physics with multiple spin substates — •Chris H Greene — Purdue University, West Lafayette, Indiana, USA

The Efimov effect for three particles has some novel features when each particle can reside in more than one degenerate spin substate.[1] In the context of Bose-Einstein condensation, such systems are referred to a spinor condensates, and we can similarly refer to this few-body analog as a spinor three-body problem. Some of the effects we predict for this system, in the regime of large scattering lengths, include the occurrence of multiple Efimov channels with multiple universal exponents, in addition to some multichannel spectral features. [1] V. E. Colussi et al., Phys. Rev. Lett. 113, 045302 (2014)

SYEP 2.3 Mon 15:30 C/gHS

Few-body physics induced by p-wave resonance — •Maxim A. Efremov and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, Germany

One of the most intriguing phenomenon of few-body physics is the Efimov effect [1], which manifests itself in an infinite number of weakly bound three-body states if at least two of the three two-body subsystems exhibit a single weakly s-wave bound state or resonance.

We present novel class of purely quantum-mechanical bound states in the system of three particles provided: (i) the system consists of a light particle and two heavy bosonic ones, (ii) the heavy-light short-range potential has a p-wave resonance, and (iii) all three particles move in either three [2] or two [3] space dimensions. In the case of an exact p-wave resonance and *three dimensions*, the effective potential between the two heavy particles is attractive and of long-range, supporting a *finite* number of bound states, with the spectrum strongly determined by the parameters of the underlying p-wave resonance. However, in *two dimensions*, the effective potential between the two heavy particles is attractive and of long-range, resulting in an *infinite* number of the universal bound states. Moreover, due to the weak dependence of the effective potential on the parameters of the planar p-wave resonance, the two-dimensional three-body bound states display a Coulomb series with a Gaussian cut-off governed solely by the mass ratio. [1] V. Efimov, Phys. Lett. B 33, 563 (1970) [2] M.A. Efremov, L. Plimak, M.Yu. Ivanov, and W.P. Schleich, PRL 111, 113201 (2013) [3] M.A. Efremov and W.P. Schleich, arXiv:1407.3352

SYEP 2.4 Mon 15:45 C/gHS

An optically trapped mixture of metastable helium and rubidium — •Adonis Flores, Hari Prasad Mishra, Wim Vassen, and Steven Knoop — LaserLaB, Department of Physics and Astronomy, VU University Amsterdam, The Netherlands

We report on our efforts to realize an ultracold mixture of metastable triplet ^{4}He and ^{87}Rb in an optical dipole trap (ODT). This extreme mass-imbalanced mixture is interesting for investigating the Efimov trimer spectrum, in particular to test its scale invariance [1]. Recently, we have realized a BEC of ^{87}Rb in the $F = 2$, $m_F = 2$ hyperfine substate in a hybrid trap [2], consisting of a quadrupole magnetic field and a single beam ODT. We also obtain thermal clouds of 1×10^6 atoms below 1 μK in a pure single beam ODT, by ramping down the magnetic field gradient after evaporative cooling in the hybrid trap. We are currently exploring the application of the hybrid trap for metastable He. Previously, we have studied interspecies thermalization in the quadrupole magnetic trap, from which we have obtained a value of the interspecies quartet scattering length, in agreement with *ab initio* quantum chemistry calculations [3]. Once we have obtained an ultracold mixture in the ODT we will study interspecies Penning ionization for different spin mixtures and search for interspecies Feshbach resonances.

[1] R. Pires *et al.*, Phys. Rev. Lett. 112, 250404 (2014)
[2] H. P. Mishra, A. S. Flores, W. Vassen, and S. Knoop, arXiv:1411.7628
[3] S. Knoop *et al.*, Phys. Rev. A 90, 022709 (2014)

SYEP 2.5 Mon 16:00 C/gHS

Efimov physics in an ultracold Bose-Fermi mixture of ^{133}Cs and ^{6}Li — •Juris Ulmanis, Rico Pires, Stephan Häfner, Alda Arias, Eva D. Kuhnle, and Matthias Weidemüller — Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Ultracold Bose-Fermi mixture of Cs and Li constitute a prototypical system with mass imbalance that allows exploration of many intriguing phenomena in few- and many-body physics. One of such is the heteronuclear Efimov effect, due to which an infinite geometrical series of bound three-body states can be formed, given that the two-body interactions are resonant. Here we present the recent observations of two consecutive Efimov resonances through measurements of three-body loss coefficients near the broad Feshbach resonance [1]. In order to precisely map the applied magnetic field onto the scattering length we extend our previous analysis of Feshbach resonances [2] with radio-frequency association of LiCs Feshbach molecules. We measure the dimer binding energies close to Feshbach resonances and extract Li-Cs scattering properties from them. The new mapping allows us to obtain refined positions and scaling of the Efimov resonances, which slightly deviates from the predicted universal scaling factor for the LiCs system.

[1] R. Pires *et al.*, PRL **112**, 250404 (2014)
[2] R. Pires *et al.*, PRA **90**, 012710 (2014)

SYEP 2.6 Mon 16:15 C/gHS

Z_b-B scattering in pionless effective field theory — •Erik Wilbring[1], Hans-Werner Hammer[2], and Ulf-G. Meissner[1,3] — [1]Helmholtz-Institut für Strahlen- und Kernphysik (Theorie) and Bethe Center for Theoretical Physics, Universität Bonn, D-53115 Bonn, Germany — [2]Institut für Kernphysik, TU Darmstadt, D-64289 Darmstadt, Germany — [3]Institut für Kernphysik (IKP-3), Institute for Advanced Simulation (IAS-4) and Jülich Center for Hadron Physics, Forschungszentrum Jülich, D-52425 Jülich, Germany

The two charged exotic mesons $Z_b(10610)$ and $Z_b'(10650)$ found by the Belle collaboration are interpreted as hadronic molecules made of two loosely-bound B-mesons. Motivated by their relatively small binding energies, we analyze their scattering off a third B-meson using a non-relativistic effective field theory without pions. In analogy to the deuteron considered as a NN bound state and the triton as the first Efimov trimer in the NNN system, we search for possible bound states of three B-mesons which originate from the Efimov effect. In addition we determine the scattering length and phase shift of different elastic Z_b–B-meson scattering processes by numerically solving the corresponding (coupled) integral equations.