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How to Study Efimov States in Exotic Nuclei

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The structure of halo nuclei is a subject of intense research in nuclear physics. Of particular interest in three body systems is the existence of Efimov states [1]. This special class of Borromean states appear when the scattering length associated with the underlying two-body force is much larger than its range. Interestingly, Efimov, in his original publication, used nuclear states as possible examples. To date, however, no evidence for such states have been found in nuclei and only recently in ultracold Cs atoms [2]. In recent works [3,4], 20C has been suggested as a potential candidate for which an excited Efimov state exists. Other cases may include 19B [5] and 60Ca [6].

In ref. [4], Canham and Hammer study the universal properties of halo nuclei on the basis of an effective field theory. This approach provides an excellent tool, given the separation of energy scales, to treat the nucleus as an effective three body system of the form neutron-neutron-Core. The properties of these states scale as a function of the dimensionless universal parameter (lambda0) which in the limit of large core masses approaches ~16.

In this work, we ask ourselves how can we study these intriguing states in
exotic nuclei ? Mazumdar et al. [3] have suggested the study of Fano resonances in neutron scattering but this is not possible at this time. Here, we envision a few alternatives that should be explored. In particular, if nucleus Z[A]N is a potential candidate, we consider:

1) One neutron transfer: Z[A-1] N-1 (d,p) A, as a surrogate of the neutron scattering,

2) Two-neutron transfer: Z[A-2]N-2 (t,p) A , and

3) Inelastic scattering: A (x,x').

We will present simple arguments to estimate the cross sections for these reactions in terms of the scaling parameter and discuss possible implications. We hope that these initial estimates will serve as a starting point for more refined and realistic calculations which will be required for careful experimental planning and further analysis.

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[6] G.Hagen et al. PRL 111 (2013) 132501

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