The structures of exotic nuclei from analyses of nucleon-nucleus scattering data.

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Elastic and inelastic scattering data can be, and have been, used to probe details of model structures assumed for the nucleus. Current methods of analysis also allow prediction of structures of nuclei that are yet to be tested experimentally. Of all such processes, those of scattering of nucleons from nuclei, and via inverse kinematics, of radio-active ion beams from hydrogen targets, are among the best that can be analysed to probe details of structure within the nuclear medium.

Low energy cross sections from the collision of nucleons with (light mass) nuclei show sharp, as well as broad, resonances lying upon a smooth, energy-dependent background. Those resonances correlate to states in the discrete spectrum of the target. To interpret such scattering data then requires use of a complex coupled-channel reaction theory. I will discuss one such theory; one that has very important improvements over those used heretofore. This theory, a multi-channel algebraic scattering (MCAS) theory, specifies a means to find solutions of the coupled Lippmann-Schwinger equations for the scattering of two quantal systems. It is best framed in momentum space.

The prime information sought are the scattering (S) matrices which are extracted from the T-matrices generated by MCAS. The approach employs matrix methods built using sturmian-state expansions of whatever matrix of nucleon-nucleus interactions one chooses to describe the scattering processes, and is designed to incorporate the effects of the Pauli exclusion principle. With this method, all resonances in any energy range can be identified and their centroids, widths, and spin-parities determined. Similarly the energies and spin-parities of bound (sub-threshold) states of the compound system can be determined since the procedure can be used for negative energies in the nucleon-nucleus system.

To analyse scattering data taken at higher energies, typically of many tens of MeV, for which the MCAS method may be intractable, we can use the g-folding prescription to define optical potentials with which elastic scattering data can be assessed. This has been done successfully but success requires that the exact non-locality of those optical potentials arising from the effect of the Pauli principle and allowance for a medium dependence of the effective interaction between the incident nucleon and any one bound in the target be taken into account. A good nucleon-based model of the ground state structure of the target is also needed. Then, with those optical potentials defining the relative motion (distorted) wave functions, a distorted wave approximation (DWA) can be used to assess inelastic scattering data.

Examples of the successful application of the various methods will be given and then all applied to use the available data to assay the structures of the carbon isotopes $^{10-19}$C.