MCAS: A multichannel algebraic scattering theory of low energy nuclear scattering and sub-threshold spectra.

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Low energy cross sections from the collision of nucleons with light mass nuclei show sharp as well as broad resonances upon a smooth, energy dependent background. Those resonances may 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. We have developed such a theory; one that has very important improvements over those used heretofore. This theory, a multi-channel algebraic scattering (MCAS) theory, finds solution of the coupled Lippmann-Schwinger equations for the scattering of two quantal systems in momentum space, and is a quite general one. To date, however, we have limited study to nucleon scattering from targets of zero ground state spin.

The prime information sought are the scattering (S) matrices which are easily extracted from the T-matrices generated by MCAS. The approach involves using matrix methods built using sturmian-state expansions of the relevant nucleon-nucleus potential matrix. 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 states of the compound system sub-threshold can be determined.

It has long been assumed that collective model prescriptions of nucleon-nucleus scattering violated the Pauli principle. Heretofore that has been the case. However, the MCAS procedure enables use of an orthogonalizing pseudo-potential approximation by which such Pauli principle violation can be alleviated. Doing so is crucial to finding the parameter values of the interaction that simultaneously gives the sub-threshold compound nucleus spectrum and the low energy scattering cross sections.

Results are presented for the well-studied scattering of neutrons and protons from ^{12}C. For energies up to 10 MeV in the compound nucleus, all compound and quasi-compound resonances observed in total cross-section data are well reproduced, and the sub-threshold states in ^{13}C and ^{13}N are predicted with correct spin-parities, and at reasonable energies. Preliminary results for proton and neutron scattering from ^{6}He will be shown as will a more ambitious use for the sub-threshold information on the ^{3}He+^{12}C system.

Any form for the initial matrix of coupled-channel potentials can be used and we are studying those arising from a vibration model of nucleon-nucleus reactions as well as those of a shell model description of the target structure. The MCAS theory also lends itself to specification of an equivalent optical model potential and first results indicate that such is extremely non-local. Examples will be shown, time permitting.