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The Contribution Path Picture of Flows for the s, i, and r Processes

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The s, i, and r processes are neutron-capture nucleosynthetic channels that occur at different neutron densities. Modern reaction network calculations follow these processes in great detail in models of stellar environments, but those calculations do not necessarily provide a full but straightforward quantitative accounting of the flow of abundance from one species to another. This talk will present the matrix-tree and matrix-forest theorems from graph theory and apply them to the question of network flows. Under the often useful assumption of constant neutron density and temperature, the theorems lead to elegant analytic solutions of the contribution of the abundance of one species to another in s and i process nucleosynthesis. Such solutions give a valuable picture of network flows and provide a quantitative estimate of the role of individual reactions in final abundance yields. For the r process, the theorems lead to quantitative analysis of network flows over a time step throughout r-process evolution from the $(n, \gamma) - (\gamma, n)$ equilibrium phase through freeze out. This permits a detailed analysis of the evolution of particular abundance features in r-process calculations such as freeze-out smoothing and formation of the rare-element peak.

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