Various classes of (direct) reaction

1) Elastic scattering. The simplest “reaction”. The internal states of a and A are unchanged and $Q = 0$. Written as: A(a,a)A

2) Inelastic scattering. Usually, this term is applied to a reaction where A is left in an excited state, i.e. B = A* and therefore $Q = -Ex.$ *a is then emitted* with reduced energy and the reaction is written as: A(a,a′)A*.

For complex projectiles a may be excited instead of the target or both a and A may be left in excited states (mutual excitation).

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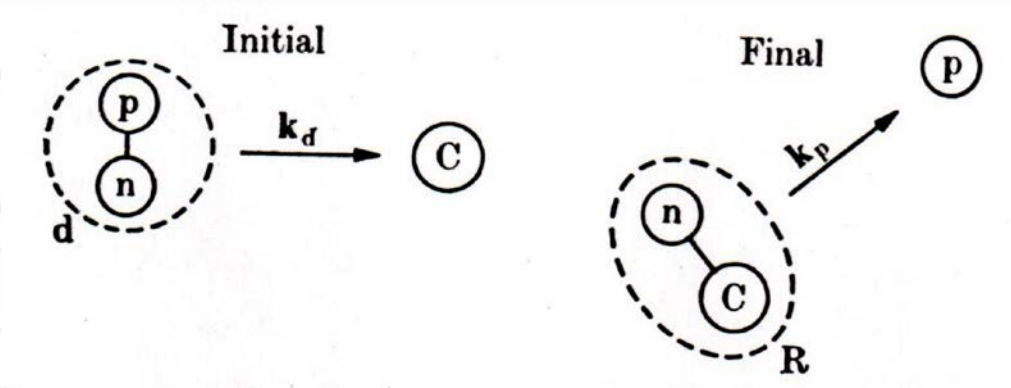
3) Transfer reactions. Here B ≠ A and b ≠ a, there has been a rearrangement (transfer) of nucleons between target and projectile.
Two sub-groups, conventionally defined in terms of the projectile:
Stripping – a nucleon or nucleons is transferred from the projectile to the target
Pickup – a nucleon or nucleons is transferred from the target to the projectile
Examples:
Stripping: 208Pb(d,p)209Pb
Pickup: 208Pb(p,d)207Pb



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4) Breakup. This is no longer a simple two-body process but (usually) a three-body one:

A(a,a*→b + c)A

i.e. a is excited to a “state” (either a resonance or the continuum) above the emission threshold for particle c (a is considered to consist of particle c bound to core b)

Example: 6Li* → α + d

Four-body (or more) breakup modes can also occur,

e.g. 6He → α + n + n

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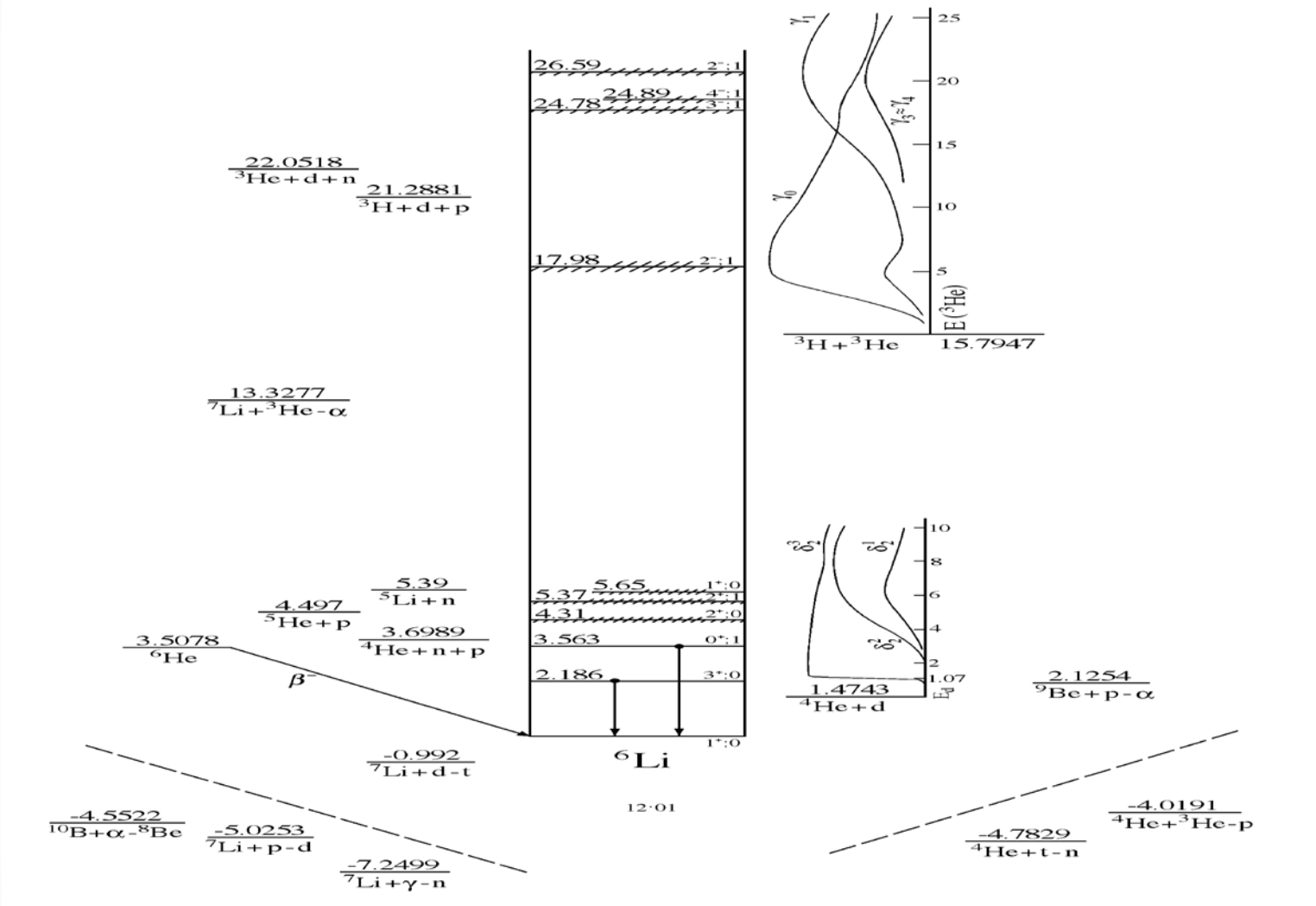

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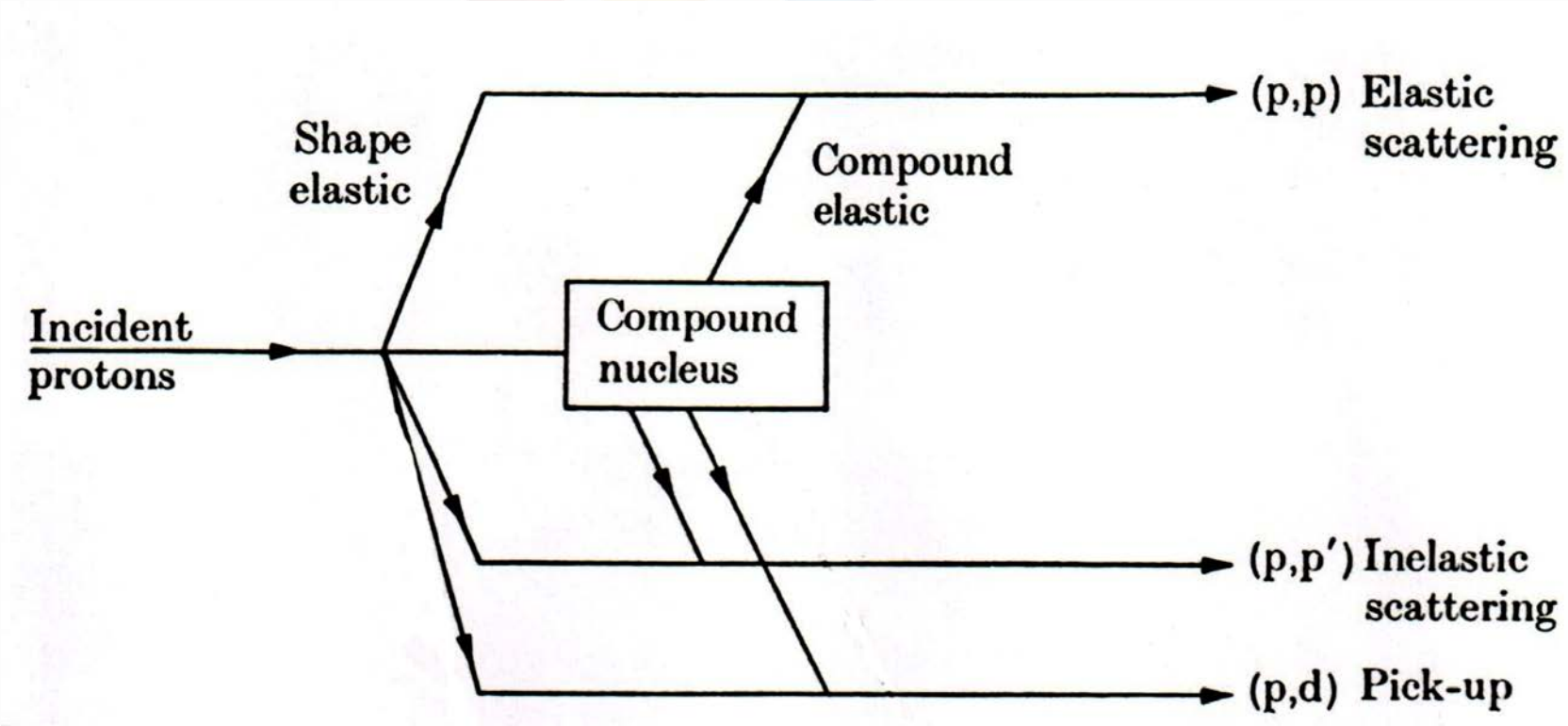
for light ions (nucleons in particular) even these reactions can have a compound component:



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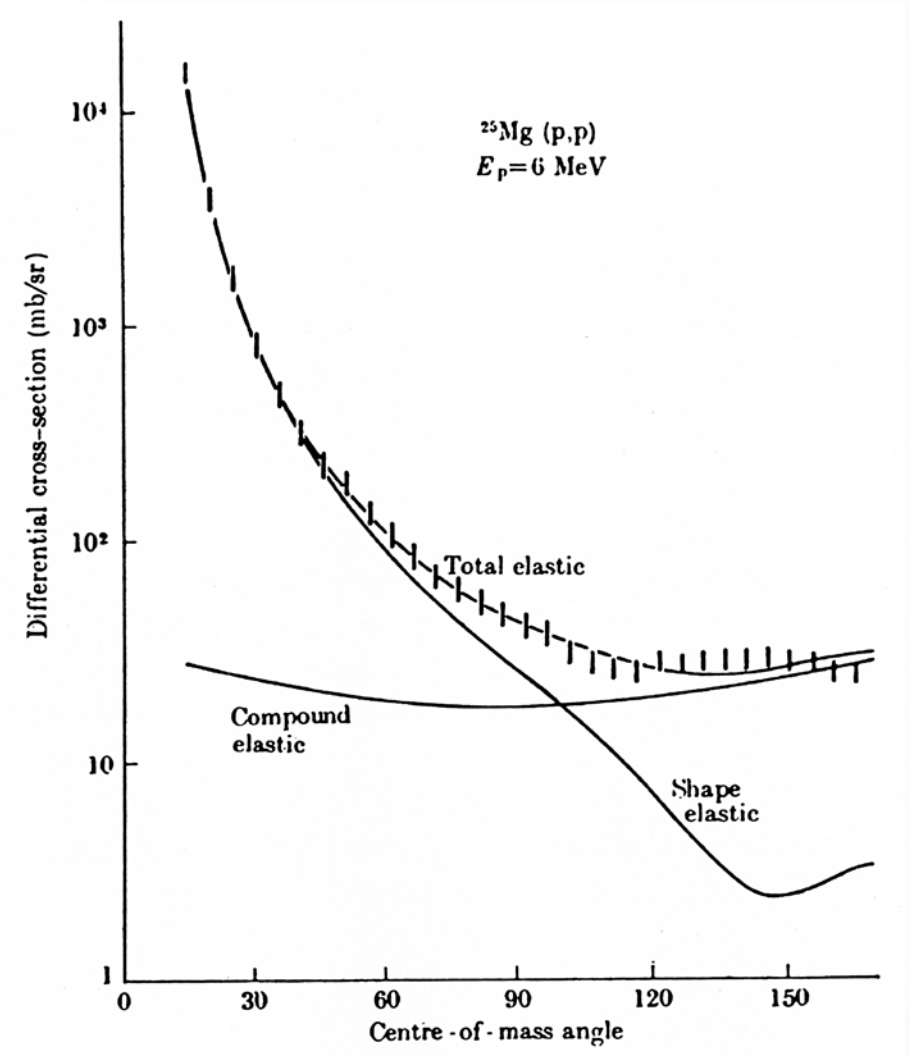
A particular case is so-called compound elastic scattering. This is only a problem for low-energy nucleon elastic scattering:



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Compound elastic scattering occurs when, after formation of the compound nucleus in an excited state, a proton (in this case) is emitted with the same energy as the incident proton. As the incident energy increases this process rapidly becomes less likely, so we only have to consider it at low energies. Fortunately, compound and shape elastic (the direct scattering process) do not interfere and can be analysed separately.

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Finally, if the projectile has exactly the right energy *resonant behaviour can occur (usually only in* elastic or inelastic scattering). This is not confined to nucleons or light ions, it can also occur for the lighter heavy ions (a heavy ion is by convention anything heavier than an α particle). However, it usually only occurs at low incident energies and we shall not consider it further here.

Reference:

1. Norman K Glendenning, Direct Nuclear reaction, World Scientific Publishing Co. Pte. Ltd.
2. Brad Sherrill, **Nuclear Structure and Reactions, Michigan State University**
3. N. Keeley: *National Centre for Nuclear Research*