Input example for inelastic scattering with collective form factors

Inelastic scattering within the rotor model: ^{10}Be + ^{1}H

Input example for ^{10}Be + ^{1}H

```
0Be+p @ 63.7 MeV/u DWBA (rotor model)
AMELIST
FRESCO hcm=0.05 rmatch=40.0
    jtmin=0.0 jtmax=50 absend=-1
    thmin=0.1 thmax=90.00
    iter=1 nnu=24
    smats=2
      xstabl=1 lin=2
      elab=63.7 /

PARTITION namep='10Be' massp=10.0113 zp=4
        namet='p' masst=1.0078 zt=1 nex=2 /
STATES jp=0.0 bandp=1 ep=0.000 cpot=1 ep=0.0 jt=0.0 /
STATES jp=2.0 bandp=1 ep=3.368 cpot=1 copyt=1 /
partition /

POT kp=1 ap=10 at=0.0 rc=1.0 /
POT kp=1 type=10 shape=10 p2=7.8 /
POT kp=1 type=1 p1=31.64 p2=1.145 p3=0.69
                  p4=8.78 p5=1.134 p6=0.69 /
POT kp=1 type=10 shape=10 p2=1.97 /
step /

pot /

overlap /

coupling /
```

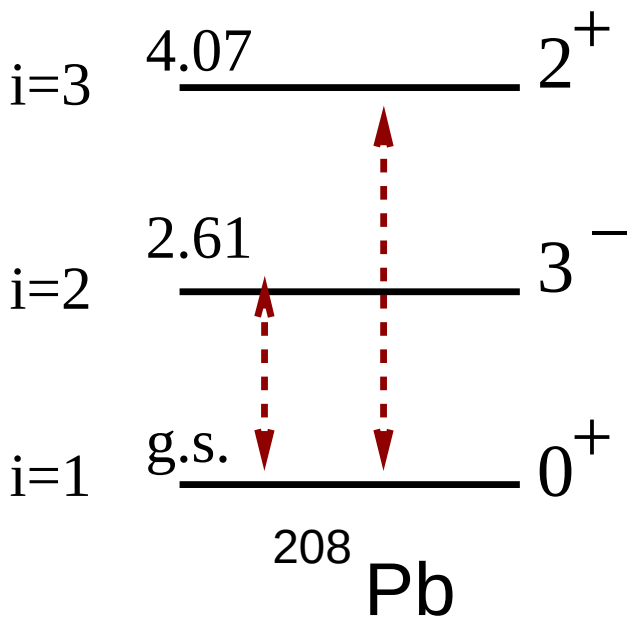
- `iter`=1: Solve CC to 1st order (DWBA)
- For the excited pair: `copyt=1`
- Coulomb deformation:

  `type`=10 (rotor)
  `shape`=10 (usual deformed charge distribution)
  `Mn`=7.8 e fm^2
- Nuclear deformation:

  `type`=10 (rotor)
  `shape`=10 (derivative of undeformed potential)
  δ_2=1.97 fm.

Collective excitations from general matrix elements

Example: ^{208}Pb(^{16}O,^{16}O)^{208}Pb(3^-,2^+)



Input example for ^{208}Pb(^{16}O,^{16}O)^{208}Pb(3^-,2^+)

Input example 2: ^{208}Pb(^{16}O,^{16}O)^{208}Pb(3^-,2^+) (o16pb-cc1a.in)

```
o16pb_cc1a.in: 16O+208Pb 80 MeV
NAMELIST
&FRESCO hcm=0.05 rmatch=100.0
        jtmin=0.0 jtmax=300.0
        thmin=5.00 thmax=-180.00 thinc=2.50
        iblock=3
        smats=2 xstabl=1 elab= 80.0 /

&PARTITION namep='16O' massp=15.99 zp=8
          namet='PB208' masst=207.98 zt=82
          nex=3 /
&STATES jp=0.0 bandp=1 ep=0.0 cpot=1
       jt=0.0 bandt=1 et=0.0   /
&STATES jp=0.0 copyp=1 ep=0.0 cpot=1
       jt=3.0 bandt=-1 et=2.61 fexch=F /
&STATES jp=0.0 copyp=1 bandp=1 ep=0.0 cpot=1
       jt=2.0 bandt=1 et=4.07 /
&partition /
```

```
&POT kp=1 itt=F ap=208.000 at=16.000 rc=1.200 /
&POT kp=1 type=13 shape=10 itt=F p2=54.45 p3=815.0
/
&STEP ib=1 ia=2 k=3 str=815.0 /
&STEP ib=2 ia=1 k=3 str=815.0 /
&STEP ib=1 ia=3 k=2 str=54.45 /
&STEP ib=3 ia=1 k=2 str=54.45 /
&step /
&POT kp=1 type=1 shape=1
p4=10.000 p5=1.000 p6=0.400 /
&POT kp=1 type=-1 p1=60.500 p2=1.179 p3=0.658 /
&POT kp=1 type=13 shape=11 p2=0.400 p3=0.8 /
&STEP ib=1 ia=2 k=3 str=0.8 /
&STEP ib=2 ia=1 k=3 str=0.8 /
&STEP ib=1 ia=3 k=2 str=0.4 /
&STEP ib=3 ia=1 k=2 str=0.4 /
&step /

&pot /

&overlap /
&coupling /
```

^{208}Pb(^{16}O,^{16}O)^{208}Pb input example

General variables:

```
&FRESCO hcm=0.05 rmatch=100.0
       jtmin=0.0 jtmax=300.0
       thmin=5.00 thmax=-180.00 thinc=2.50
       iblock=3
       smats=2 xstabl=1
     elab= 80.0 /
```

`iblock`: Number of states (including gs) that will be coupled to all orders.

- `iblock=1`: only elastic scattering
- `iblock=2`: elastic scattering + 1st inelastic channel (^{208}Pb(3^-))
- `iblock=3`: elastic scattering + ^{208}Pb(3^-) + ^{208}Pb(2^+)

^{208}Pb(^{16}O,^{16}O)^{208}Pb input example

Partitions and states:

```
&PARTITION namep='16O' massp=15.99 zp=8 namet='208Pb' masst=207.98 zt=82
           nex=3 /
&STATES jp=0.0 bandp=1 ep=0.0 cpot=1 jt=0.0 bandt=+1 et=0.00 /
&STATES      copyp=1          cpot=1 jt=3.0 bandt=-1 et=2.61 /
&STATES      copyp=1          cpot=1 jt=2.0 bandt=+1 et=4.07 /
&partition /
```

- `nex`: number of states within the partition
- `ep, et`: excitation energy for projectile / target
- `copyp=1` tells FRESCO that the 2nd and 3rd projectile states are just a copy of the ground state.

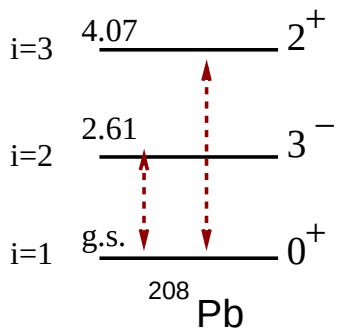
^{208}Pb(^{16}O,^{16}O)^{208}Pb input example

Coulomb excitation:

```
&POT kp=1 ap=208.000 at=16.000 rc=1.2 /
&POT kp=1 type=13 shape=10 p2=54.45 p3=815.0 p4=0 p5=0 p6=0 /
```

- `type=13`: couple target states by deforming previous potential
- `p1,...,p6`: consider couplings for multipoles k with `pk`$\neq 0$
- `shape=10`: usual deformed charge sphere: $V^k_{nm}(R) \propto M(Ek)/R^{k+1}$

```
&STEP ib=1 ia=2 k=3 str=815.0 /
&STEP ib=2 ia=1 k=3 str=815.0 /
&STEP ib=1 ia=3 k=2 str=54.45 /
&STEP ib=3 ia=1 k=2 str=54.45 /
&step /
```



- `ia, ib`: couple from state number `ia` to state `ib`
- `k`: multipolarity
- `str`=$\langle$ib$\|$M(Ek)$\|$ia$\rangle$ = $\sqrt{(2I_a+1)B(E\lambda; ia \rightarrow ib)}$

^{208}Pb(^{16}O,^{16}O)^{208}Pb input example

Nuclear excitation:

```
&POT kp=1 type=1 shape=1 p4=10.000 p5=1.000 p6=0.400 /
&POT kp=1 type=-1 shape=0 p1=60.500 p2=1.179 p3=0.658 /
&POT kp=1 type=13 shape=10 itt=F p2=0.400 p3=0.8 /
```

- `type=13`: couple target states by deforming preceding potential
- `shape=10`: usual deformed nuclear potential: $V^k_{nm}(R) \propto \delta_k dU(R)/dR$

```
&STEP ib=1 ia=2 k=3 str=0.8 /
&STEP ib=2 ia=1 k=3 str=0.8 /
&STEP ib=1 ia=3 k=2 str=0.4 /
&STEP ib=3 ia=1 k=2 str=0.4 /
```

- `str`=$\langle ib||\delta_k||ia\rangle$ (reduced deformation length)

^{208}Pb(^{16}O,^{16}O)^{208}Pb input example

Useful output files:

- Main output file:

```
0CUMULATIVE REACTION cross section                    =    11.22270  <L> =     47.07
0CUMULATIVE outgoing cross sections in partition 1 :     0.00000    7.67943     0
0Cumulative ABSORBTION by Imaginary Potentials        =     2.55189  <L> =      6.99
```

- Angular distributions:
  - `fort.201` : Elastic scattering angular distribution
  - `fort.202` : 1st state angular distribution
  - `fort.203` : 2nd excited state angular distribution

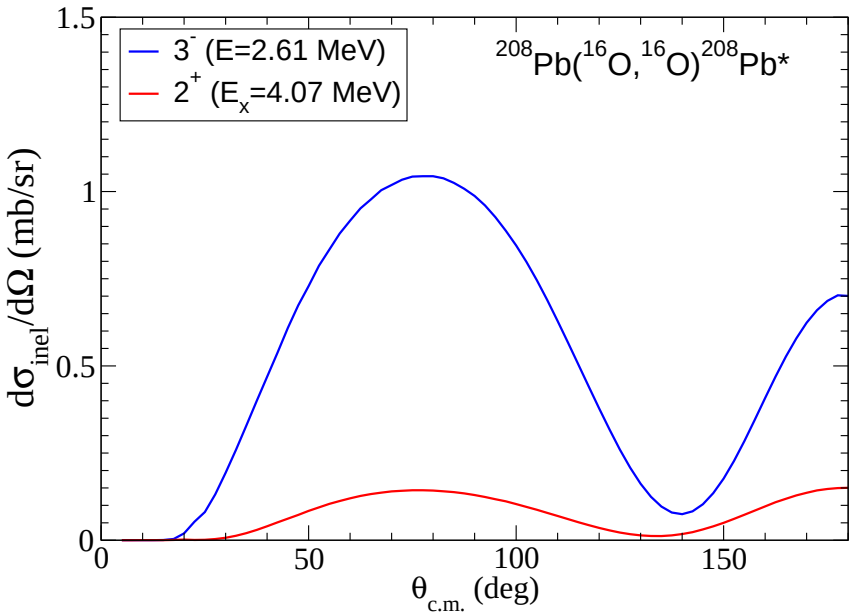
- `fort.56`: 3 columns: Fusion (absorption), reaction and inelastic cross section for each total angular momentum J.

$$\sigma_{\rm reac} = \sigma_{\rm inel} + \sigma_{\rm abs}$$

^{208}Pb(^{16}O,^{16}O)^{208}Pb inelastic scattering

Angular distribution of the ejectile in c.m. frame

Absolute cross section



Ratio to elastic cross section