

# *TROPIC: A Python Program for Calculating Reduced Transition Probabilities*

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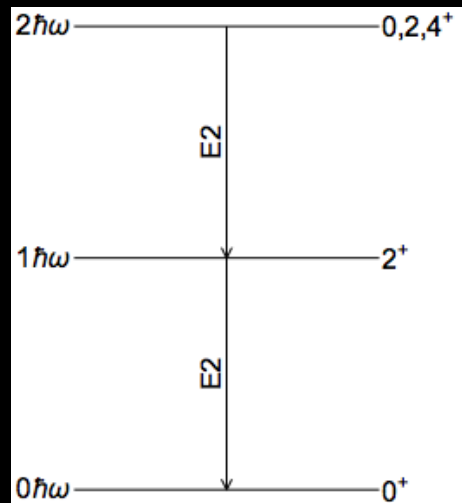
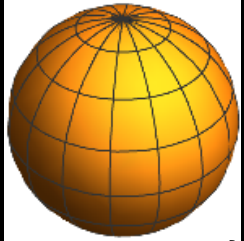
29<sup>th</sup> INPC

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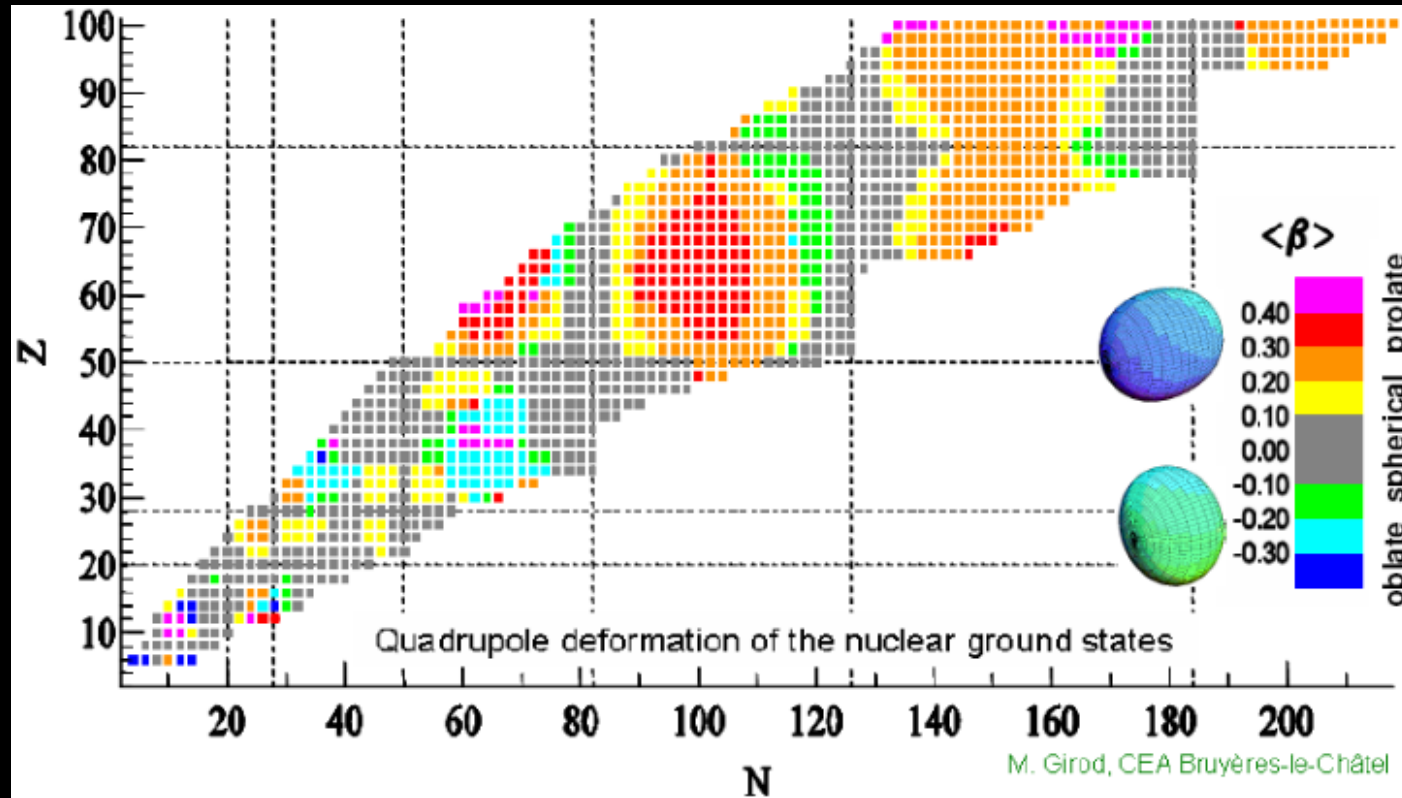


# Motivation

Spherical



$$E = N\hbar\omega$$

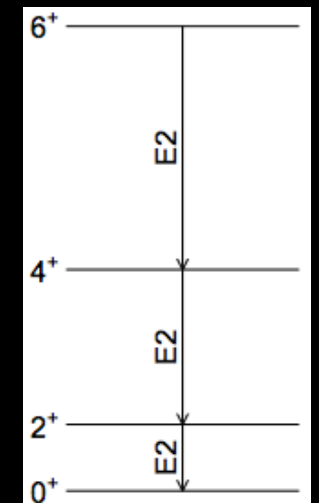
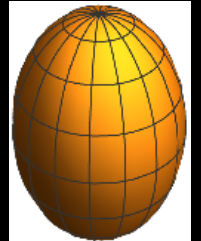


Deformed nuclei between closed shells

Rare earth region: most deformed

What kind of excitations are possible?

Deformed



$$E \propto J(J + 1)$$

# *Experimental Data Needed*

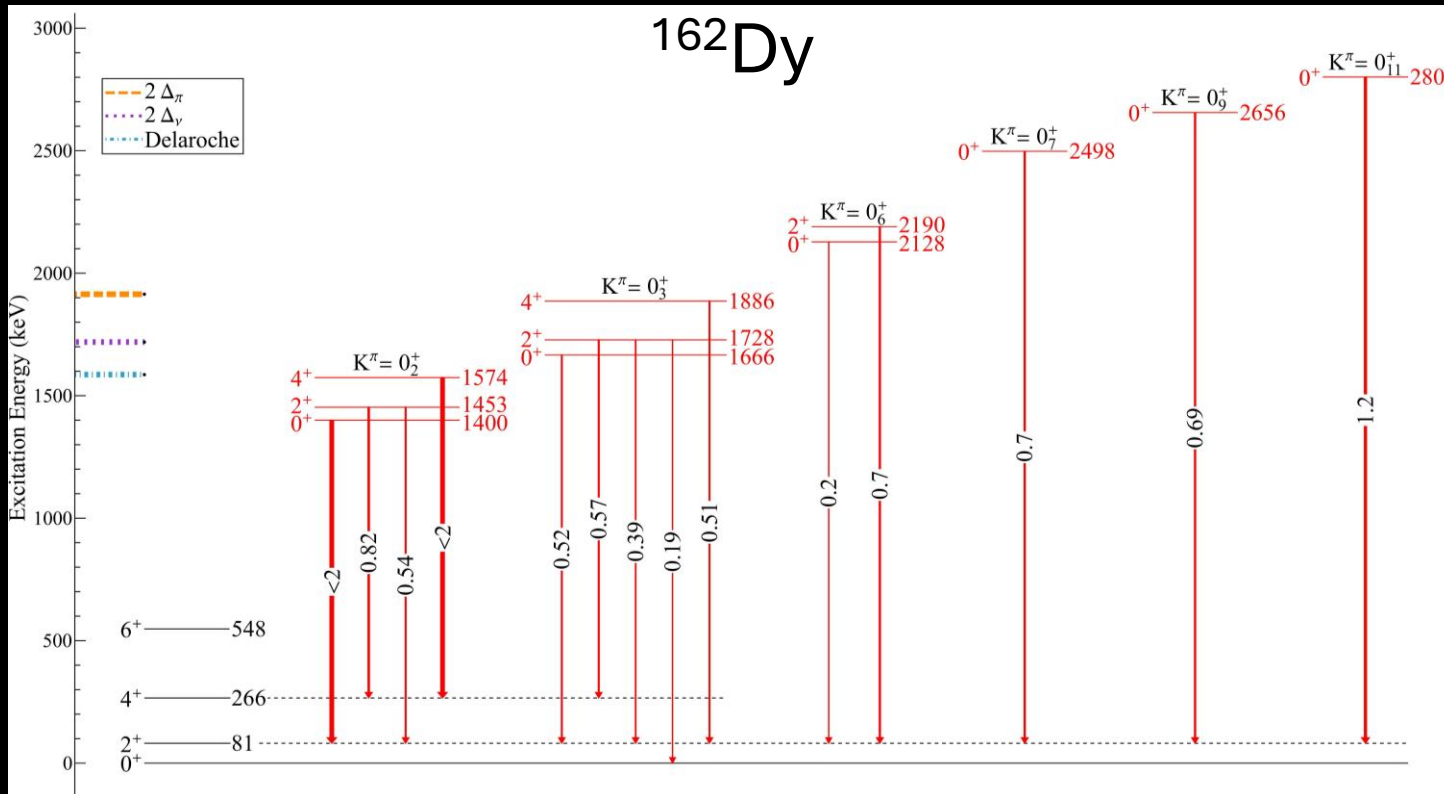
1. Transfer reactions  $\rightarrow$  Identify  $0^+$  states
2. Lifetime measurements  $\rightarrow$   $B(E2)$  values
3.  $E0$  measurements  $\rightarrow$   $\rho(E0)$  values

## *Recent Reviews*

$0^+$  states and  $B(E2)$ 's: Aprahamian et al., PPNP (2025)  
<https://doi.org/10.1016/j.pnpnp.2025.104173>

$E0$  transitions: Kibedi et al., PPNP (2022)  
<https://doi.org/10.1016/j.pnpnp.2021.103930>

# Lifetime Measurements



Aprahamian et al., Eur. Phys. J. A (2024)

Needed to obtain **transition probabilities**

Measurements done at ILL Grenoble and UKY  
 $^{178}\text{Hf}$ ,  $^{156}\text{Gd}$ ,  $^{158}\text{Gd}$ ,  $^{162}\text{Dy}$ ,  $^{168}\text{Er}$

Method to calculate B(E2) values efficiently

# Available Methods

**TRANSNUCLEAR** by University of Cologne

Written in Perl

Calculates transitions for single level

All information inputted via terminal prompts

**RULER** by ENSDF / NSDD

Written in Java

Calculates transitions for multiple levels

Input format based off 80-character punch card

Can use Excel (requires Excel2ENSDF)

172YB	L	0.0		0+						A
172YB	L	78.7427	6	2+		1.65	NS	5		A
172YB	G	78.7426	6	100	E2				8.4	
172YB	L	260.268	5	4+		0.122	NS	8		A
172YB	G	181.528	4	100	E2				0.376	
172YB	L	539.977	6	6+		16.6	PS	15		A
172YB	G	279.717	5	100	E2				0.092	

# TROPIC

TRansitiOn ProbabIlity Calculator

Written in Python

Calculate transition probabilities

Prioritize **Ease of use + fast calculations**

# Inputs

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	A	E_level_(keV)	tau_(fs)	tau_err_up(fs)	tau_err_down(fs)	E_g_(keV)	E_g_err_(keV)	I	I_err	alpha	alpha_err	multipolarity	delta	delta_err_up	delta_err_down	
2	172	78.7427	2380447	72135	72135	78.7426	0.0006	100		8.4		E2				
3	172	260.268	176009	11542	11542	181.528	0.004	100		0.376		E2				
4	172	539.977	23949	2164	2164	279.717	0.005	100		0.092		E2				
5	172	1042.914	4761	1298	1298	964.09	0.05	100				E2				
6								0.173	0.016							E0 transition
7	172	1117.874	5338	577	577	857.636	0.007	100	3			E2				
8						1039.15	0.01	100	3			M1/E2	2.3	0.5	0.3	
9						1117.94	0.03	36	3			E2				

CSV file for all required parameters

```

Enter csv filename (LEAVE OUT file extension): example
Using the input parameters from: /path/to/directory/example.csv
Output files placed at: /path/to/directory/

Enter number of decimal places to report in results (Enter an integer): 2

Enter threshold for propagating errors by using Min/Max method (e.g. enter 0.1 for 10%, leave blank for standard error propagation): 0.1
Using Min/Max method when uncertainty is above 10.0%

Do you want to see the Weisskopf unit conversion? [Y/N]: y
  
```

Few prompts in terminal



# Outputs



	A	B	C	D	E	F	G	H	I	J	K	
1	A	E <sub>lev</sub> (keV)	tau (fs)	E <sub>gamma</sub> (keV)	E <sub>f</sub> (keV)	Intensity	ICC	Multipolarity	B(pi*l)	B(pi*l)_err_up	B(pi*l)_err_down	Unit
2	172	78.7427	2380447	78.7426	0	100	8.4	E2	212.05	6.63	6.24	W.u.
3	172	260.268	176009	181.528	78.74	100	0.376	E2	300.89	21.15	18.55	W.u.

CSV output

A	E <sub>lev</sub> (keV)	$\tau$ (fs)	E <sub><math>\gamma</math></sub> (keV)	E <sub>f</sub> (keV)	Intensity	$\alpha$	$\pi\ell$	B( $\pi\ell$ )
172	78.7427	2380447(72135)	78.7426(5)	0.0	100	8.4	E2	212.05 <sup>+6.63</sup> <sub>-6.24</sub> W.u.
172	260.268	176009(11542)	181.528(4)	78.74	100	0.376	E2	300.89 <sup>+21.15</sup> <sub>-18.55</sub> W.u.

Latex table output

Calculation Results:

-----  
A: 172 | E<sub>lev</sub> (keV): 78.7427 | tau (fs): 2380447.0

Transitions for this level:

E<sub>gamma</sub> (keV) | E<sub>f</sub> (keV) | Intensity | ICC | Multipolarity | B(pi\*l)

78.7426(5) | 0.0 | 100 | 8.4 | E2 | 212.05 +/- (6.63, 6.24) W.u.

-----  
A: 172 | E<sub>lev</sub> (keV): 260.268 | tau (fs): 176009.0

Transitions for this level:

E<sub>gamma</sub> (keV) | E<sub>f</sub> (keV) | Intensity | ICC | Multipolarity | B(pi\*l)

181.528(4) | 78.74 | 100 | 0.376 | E2 | 300.89 +/- (21.15, 18.55) W.u.

Terminal output



# Comparisons

$E_L$ (keV)	$E_\gamma$ (keV)	$\pi\lambda$	$B(\pi\lambda)$ TROPIC	$B(\pi\lambda)$ RULER	$B(\pi\lambda)$ TRANSNUCLEAR
78.7427	78.7426	$E2$	$212.1^{+6.6}_{-6.2}$	$212.1^{+6.7}_{-6.1}$	$213.0^{+6.7}_{-6.3}$
260.268	181.528	$E2$	$301^{+21}_{-19}$	$301^{+21}_{-19}$	$302^{+21}_{-19}$
539.977	279.717	$E2$	$321^{+32}_{-27}$	$321^{+31}_{-26}$	$322^{+32}_{-27}$
1042.914	964.09	$E2$	$3.6^{+1.4}_{-0.8}$	$3.6^{+1.3}_{-0.8}$	$3.6^{+1.4}_{-0.8}$
1117.874.	857.636	$E2$	$2.46^{+0.49}_{-0.39}$	$2.46^{+0.32}_{-0.25}$	$2.47^{+0.38}_{-0.31}$
	1039.149	mixed $M1$	$3.57^{+1.82}_{-1.43} \times 10^{-4}$	$3.57 \pm 1.06 \times 10^{-4}$	$3.57^{+1.07}_{-1.19} \times 10^{-4}$
		mixed $E2$	$0.79^{+0.21}_{-0.16}$	$0.79^{+0.11}_{-0.09}$	$0.79^{+0.33}_{-0.19}$

# *Availability*

GitHub repository: [github.com/ND-fIREBall/TROPIC](https://github.com/ND-fIREBall/TROPIC)

CPC Publication: <https://doi.org/10.1016/j.cpc.2024.109383>

Includes: Python script, example files, user guide

Feedback appreciated!



# Acknowledgements

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