Reassessing the Vibrational Nuclear Structure of ^{112}Cd

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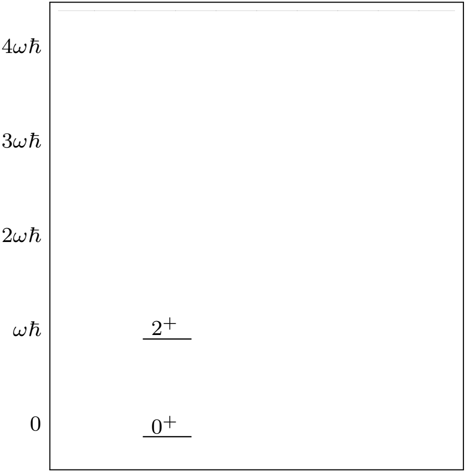
- The $\lambda = 1$ mode is a dipole vibration, which corresponds to shifts in the nuclear centre of mass

Vibration in the $^{112}\mathrm{Cd}$

Quadrupole-Octupole Vibrational Spectrum



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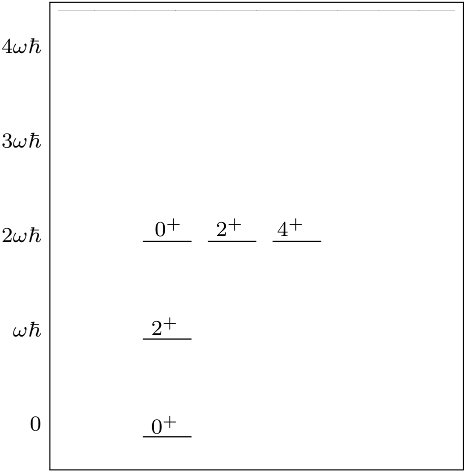

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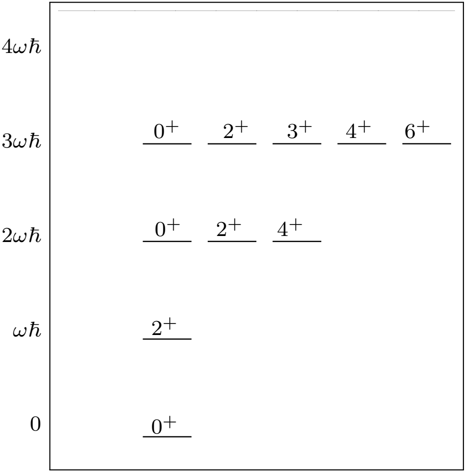

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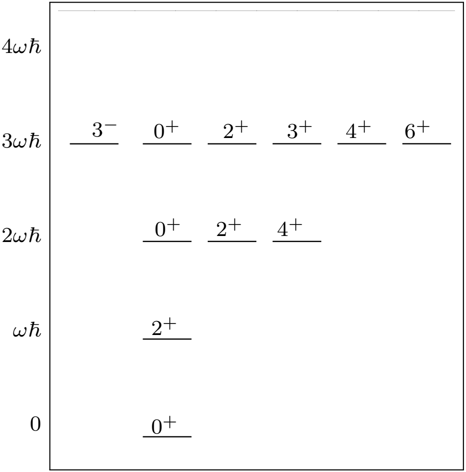

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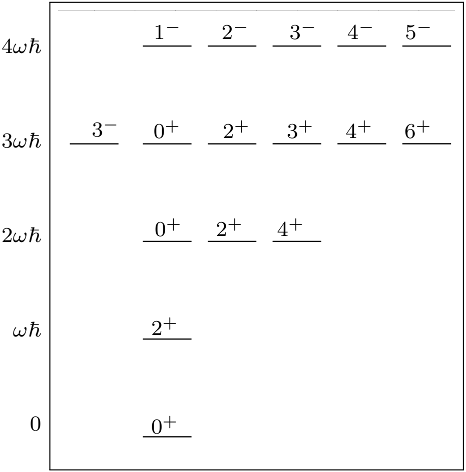

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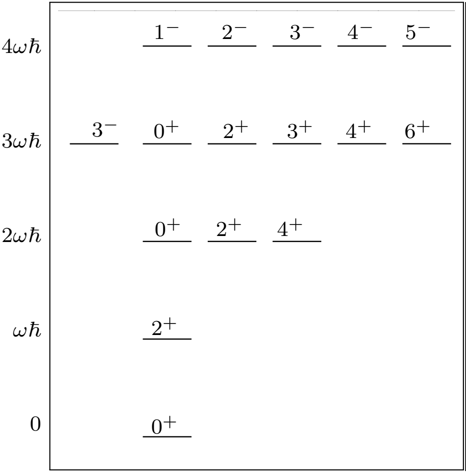
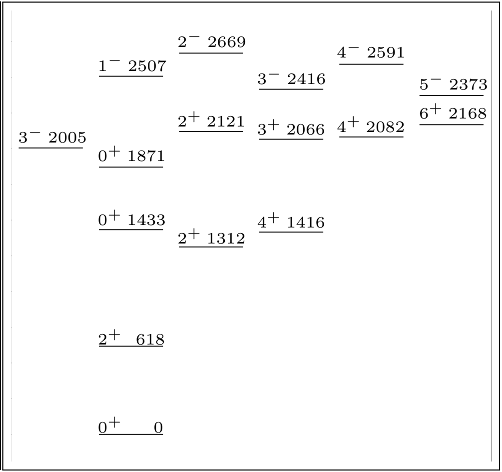


Spectrum of low-lying states in ^{112}Cd



Sources of Inconsistency in the Vibrational Interpretation

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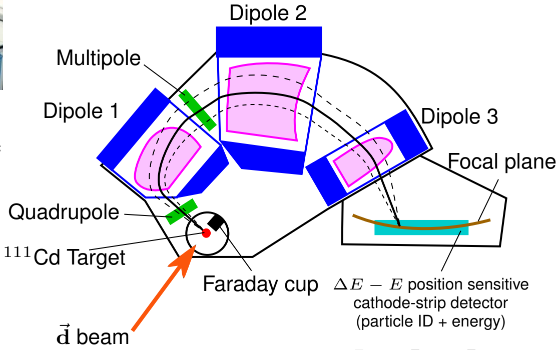
  - lifetimes
  - composition of wave-functions
- Using the $^{111}\mathrm{Cd}(\vec{\mathrm{d}},\mathrm{p})^{112}\mathrm{Cd}$ reaction, single-particle component of states in $^{112}\mathrm{Cd}$ can be measured
  - populate states in $^{112}\mathrm{Cd}$ through single neutron transfer

Maier-Leibnitz Laboratory and the Q3D

- Polarized deuterons accelerated to 22 MeV with a tandem Van de Graaff accelerator



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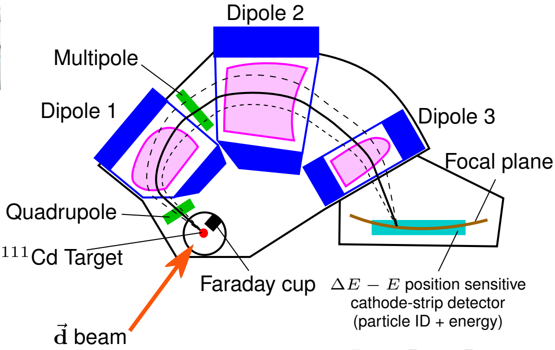

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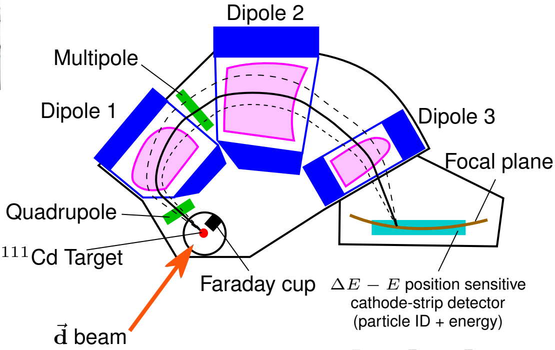

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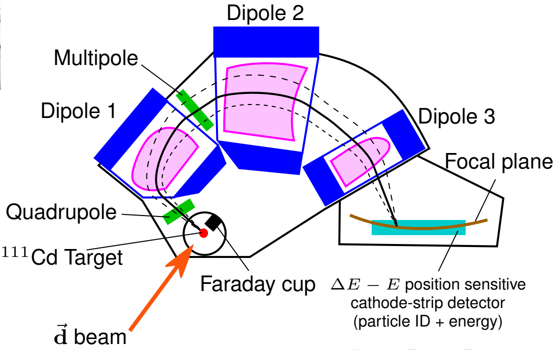

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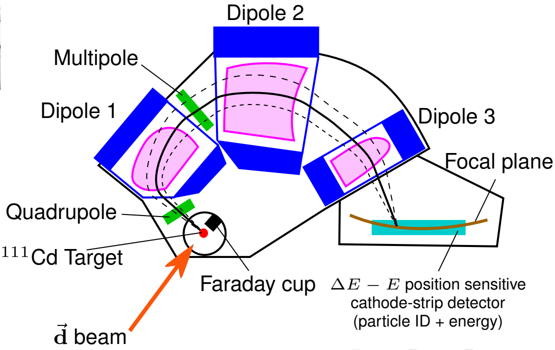
- Elastic scattering data and $(\vec{d}, p)$ transfer data were collected at angles between 10° and 60°



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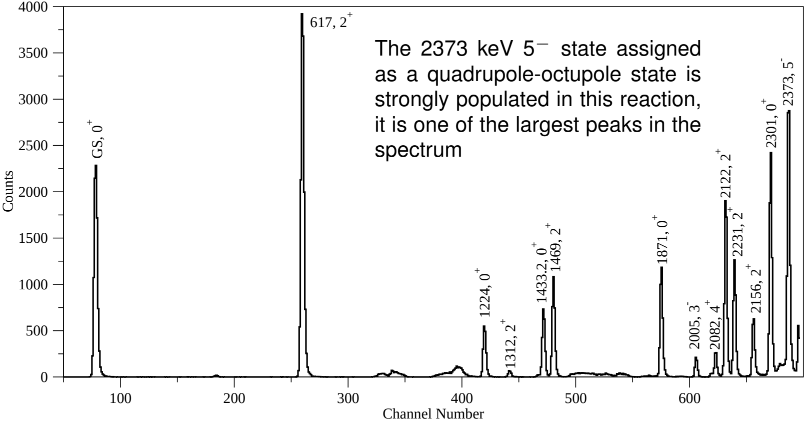
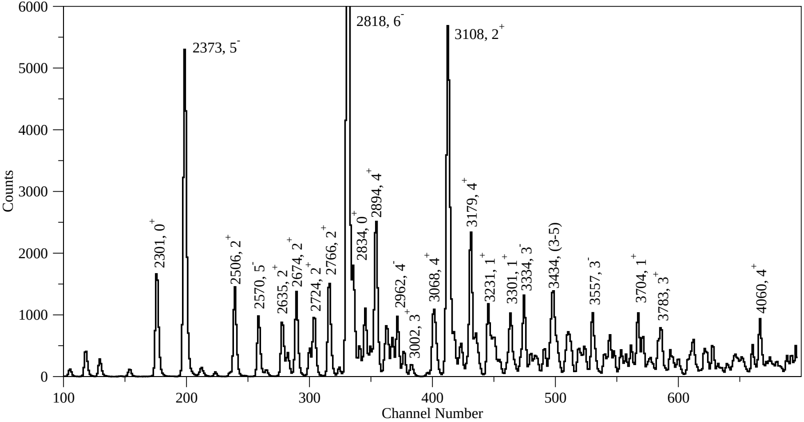
^{112}Cd Spectrum from the $\vec{\mathrm{d}}$,p reaction

Low excitation energy from 0 keV to 2380 keV at 20° with beam polarization up



^{112}Cd Spectrum from the $\vec{\mathrm{d}}$,p reaction

High excitation energy from 2000 keV to 4300 keV at 40° with beam polarization up



DWBA Calculations and Spectroscopic Factors

- Distorted-Wave Born Approximation calculations are performed and compared to the experimental data

$$U = U_{\text{bind}} + U_{\text{int}}$$

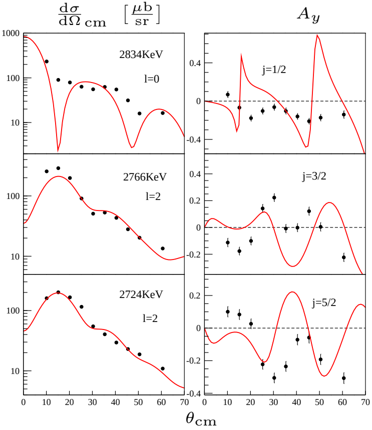
  - Interactions with nuclear volume are given by a Wood-Saxon potential
  - Surface-dominated interactions are given by the derivative of a Wood-Saxon potential

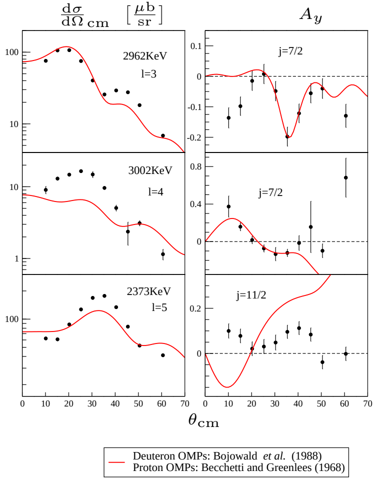
$$U_{\text{v}} = V_r \frac{1}{1 - \exp(\frac{r-R_r}{a_r})} + iW_{\text{v}} \frac{1}{1 - \exp(\frac{r-R_i}{a_i})}$$

$$U_s = i4a_i W_s \frac{\text{d}}{\text{dr}} \left(\frac{1}{1 - \exp(\frac{r-R_i}{a_i})} \right)$$

$$U_{\text{so}} = V_{\text{so}} \frac{\lambda_\pi^2}{r_{\text{so}}} \frac{\text{d}}{\text{dr}} \left(\frac{1}{1 - \exp(\frac{r-R_{\text{so}}}{a_{\text{so}}})} \right) \vec{l} \cdot \vec{s}$$

Transfer Angular Distributions DWBA





$$\frac{d\sigma}{d\Omega}_{\mathrm{EXP}} = S_{lj} \frac{d\sigma}{d\Omega}_{\mathrm{DWBA}}$$

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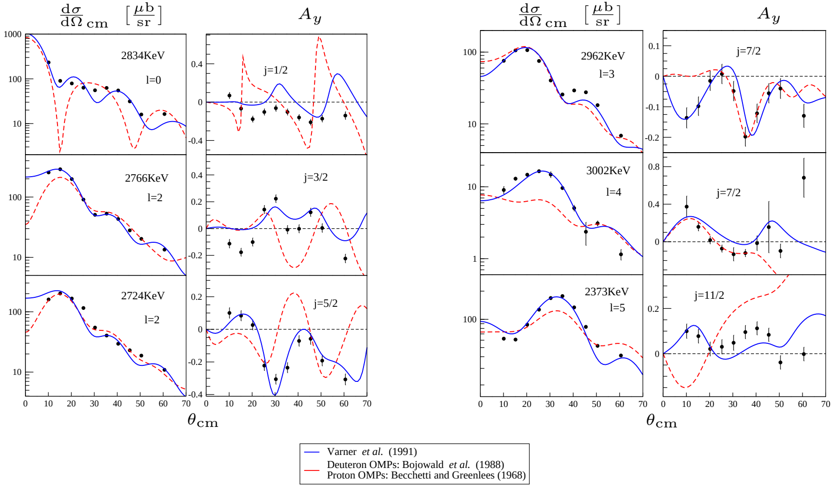
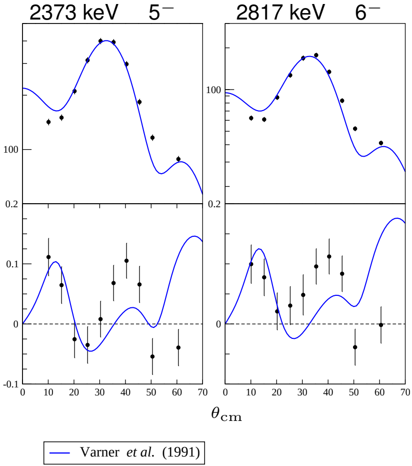
- The optical model potential for the adiabatic calculation is the sum of a proton and neutron potential, evaluated at half the deuteron energy

Transfer Angular Distributions ADWA



Reassignment and the Quadrupole-Octupole States

- The 2373 keV, 5^- state previously assigned to the quadrupole-octupole quintuplet shows strong $1\mathrm{h}_{\frac{11}{2}}$ characteristics



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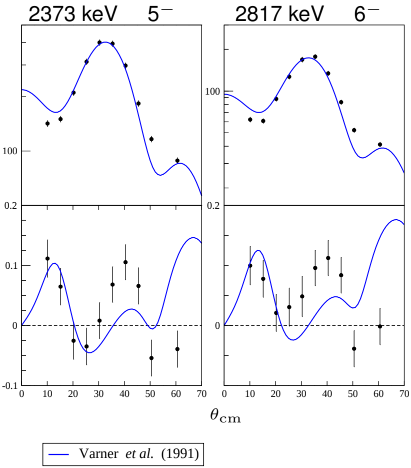
- The 2817 keV 6^- state also shows strong $1h_{\frac{11}{2}}$ characteristics



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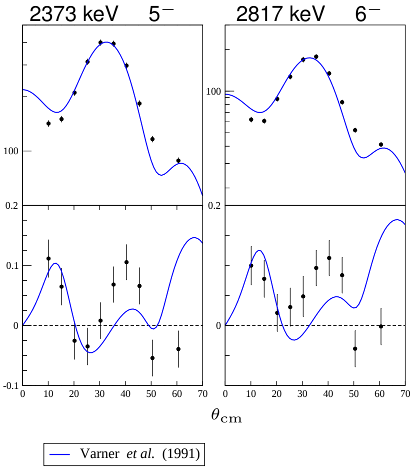

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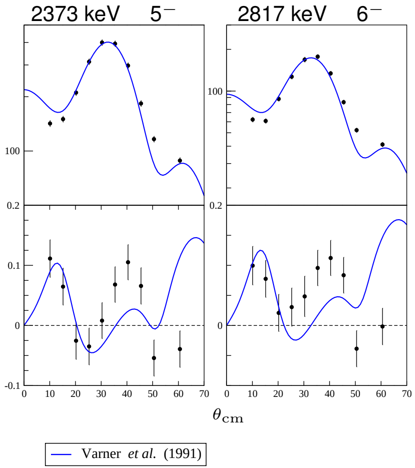
- both of these 5^- and 6^- states are strongly populated in this single neutron transfer reactions
- this data suggests the wavefunctions of these two states are dominated by a $3s_{\frac{1}{2}} \otimes 1h_{\frac{11}{2}}$ configuration



Summary

- Born approximation, with global OMPs does not reproduce the angular distributions and analyzing powers of the $^{111}\mathrm{Cd}(\vec{\mathrm{d}}, \mathrm{p})^{112}\mathrm{Cd}$ reaction well
- Adiabatic approximation gives improved reproduction of the data, compared with DWBA
- A systematic comparrison of spectroscopic factors obtained from AWDA and DWBA calculations will be made
- A strong population of the 5^- state previously assigned to the quadrupole-octupole quintuplet demonstrates a large single-particle component in the wavefunction, which is at odds with the assignment of this state within the vibrational model.
- Once spectroscopic strengths are obtained for each populated state, a reinterpretation of the vibrational spectrum of $^{112}\mathrm{Cd}$ will need to be made on the basis of the single particle components of the observed states

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LMU Ludwig-Maximilians-Universität München

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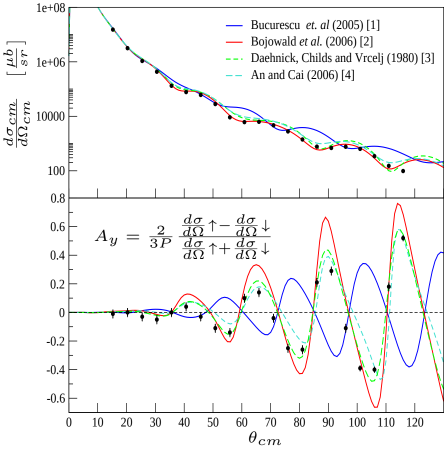
Deuteron Elastic Scattering on ^{111}Cd

- Deuteron global optical model parameter sets (OMPs) reproduce the $^{111}Cd(\vec{d},\vec{d}')^{111}Cd$ angular distribution of elastic cross-sections and analyzing powers
- The OMPs are used in distorted-wave Born approximation (DWBA) calculations with the DWUCK4 code
- The experimental elastic cross-sections are scaled to the DWBA calculation for a determination of the target thickness, which is crucial for obtaining correct angular distributions
- DWBA calculations performed using the DWUCK4 code for elastic scattering that reproduced the data best were from Bojowald *et al.* (1988) [2]



Ex (KeV)	S_{lj} ADWA	S_{lj} DWBA	%-diff
0	0.216	0.181	17.6
618	0.0478	0.0319	39.9
1224	0.0361	0.0399	-10.0
1312	0.000137	0.0004	-98.0
1416	0.00108	0.00121	-11.4
1433	0.0535	0.0464	14.2
1469	0.00981	0.00888	10.0
1871	0.0703	0.0742	-5.4
2005	0.00339	0.00523	-42.7
2065	0.000146	0.000324	-75.7
2082	0.00896	0.00846	5.7
2122	0.0136	0.0141	-3.6
2156	0.00908	0.00929	-2.3
2231	0.00144	0.00469	-106.0
2301	0.15	0.14	6.9
2373	0.17	0.146	15.2
2817	0.341	0.268	24.0