Preliminary results on photon strength functions of $^{195}$Pt from resonance neutron radiative capture measured by DANCE experiment

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Outline

• Experiment
• Data processing
  comparison of experimental spectra with their predictions
  obtained simulations within statistical model
• Results
• Conclusion
DANCE @ LANSCE

- Moderated W target gives “white” neutron spectrum, ~14 n’s/proton
- DANCE is on a 20 m flight path / ~1 cm @ beam after collimation
- repetition rate 20 Hz
- pulse width ≈ 125 ns
- DANCE consists of 160 BaF$_2$ crystals
DANCE detector

- Measurement of cross sections of small amounts of (radioactive) samples (advanced fuel cycle, astrophysics)
- Determination of properties of resonances (spins and parities)
- Study of $\gamma$-decay of distinct neutron resonances and $\gamma$-ray strength functions
“TOF” spectrum for $^{195}\text{Pt}$
What can be compared? – Multiplicity method

Signals in adjacent Ba F$_2$ crystals are grouped in clusters – cluster multiplicity $m$
What can be compared?

Each spectrum consists of a full-energy peak which is located near the neutron separation energy $S_n$ and a low-energy tail that corresponds to cascades for which part of the emitted $\gamma$ energy escaped the detection.

Only events for which the detected $E$ is close to the full-energy peak were included in our analysis.
Experimental multi-step $\gamma$ cascades (MSC) spectra of $^{196}$Pt
Experimental spectra from different resonances $M=2$

Different levels at excitation energy of $1.5 - 3$ MeV are populated from different resonances $\Rightarrow$ the “bumps in the spectra” at $E_\gamma = 1.5 - 3$ MeV are very likely not due to any “structure” effects but due to the $\gamma$SF
DICEBOX
code for statistical model simulations of $\gamma$ decay
Simulation of $\gamma$ cascades - DICEBOX algorithm

Main assumptions:

- For nuclear levels below certain “critical energy” spin, parity and decay properties are known from experiments.
- Energies, spins and parities of the remaining levels are assumed to be a random discretization of an \textit{a priori} known level-density formula.
- A partial radiation width $\Gamma_{i\gamma}^{(XL)}$, characterizing a decay of a level $i$ to a level $f$, is a random realization of a chi-square-distributed quantity the expectation value of which is equal to
  \[ f^{(XL)}(E_\gamma) \frac{E_\gamma^{2L+1}}{\rho(E_i)}, \]
  where $f^{(XL)}$ and $\rho$ are also \textit{a priori} known.
- Selection rules governing the $\gamma$ decay are fully observed.
- Any pair of partial radiation widths $\Gamma_{i\gamma}^{(XL)}$ is statistically uncorrelated.
Main feature of DICEBOX

- There exists infinite number of artificial nuclei (nuclear realizations), obtained with the same set of level density and PSFs models, that differ in exact number of levels and intensities of transitions between each pair of them
  \[\Rightarrow \text{leads to different predictions from different nuclear realizations}\]
- DICEBOX allows us to treat predictions from different nuclear realizations
- The size of fluctuations from different nuclear realizations depends on the (observable) quantity and nucleus
- Electron conversion is taken into account correctly

DICEBOX can produce any quantity related to $\gamma$ decay

The response of the DANCE detector to the generated cascades for each nuclear realization was subsequently obtained with the help of a code based on the GEANT4 package

Oslo, May 8, 2017
Level density and Photon Strength Functions

- There exist different models of LD and $\gamma$SFs
- For LD we usually used Constant-Temperature model
- For $\gamma$SF we started with $\gamma$SF from “Oslo method” (F. Giacoppo et al., 2015) indicating a presence of strong $\gamma$SF above about 5 MeV.
- Similar $\gamma$SF shapes indicated also from other data (A.G. Bartholomew, Adv. Nucl. Phys. 7, 1973)

F. Giacoppo et al., EPJ WoC 93, 01039 (2015)
Results
(comparison of experimental and simulated spectra)
Results with the “Oslo model”
(extrapolation of $\gamma$SF down to low $E_\gamma$ according to F. Giacoppi et al.)
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Predicted multiplicity distribution shifted to lower values
Results with the “Oslo model”
(extrapolation of $\gamma$SF down to low $E_\gamma$ according to F. Giacoppo et al.)

Predicted multiplicity distribution shifted to lower values
Search for a better model

How to shift the multiplicity distribution? ... Enhance transitions with low $E_\gamma$

F. Giacoppo et al., EPJ WoC 93, 01039 (2015)
Search for a better model

How to shift the multiplicity distribution? ... Enhance transitions with low $E_\gamma$

We tried to use a constant $E1\gamma$SF at low energies – indicated by “Oslo” data from two Pt isotopes. To reproduce out spectra we needed a constant $\gamma$SF for $E_\gamma < 3$ MeV.

F. Giacoppo et al., EPJ WoC 93, 01039 (2015)
Search for a better model
How to shift the multiplicity distribution? ... Enhance transitions with low $E_\gamma$

$\gamma$SF consistent with Oslo data for $E_\gamma > 3$ MeV and constant E1 $\gamma$SF at lower $E_\gamma$
Comparison of experimental data with simulation where PSF doesn't include 7.5 MeV Pygmy Dipole Resonance
Conclusions

- Experimental coincident spectra from $^{195}\text{Pt}(n, \gamma)$ reaction measured with DANCE were compared to predictions from statistical model simulations.

- We reached a satisfactory description of the experiment data with at least one $\gamma\text{SF} + \text{LD}$ model combination - the model well reproduces “Oslo” results from $^{195}\text{Pt}(p,p')^{195}\text{Pt}$ (F. Giacoppo et al., EPJ WoC 93, 01039, 2015).

- This result can indicate that a temperature dependence of E1 $\gamma\text{SF}$ initially introduced in KMF model has universal meaning for low energy primary gamma-transitions.

- Further investigations of other variants of $\gamma\text{SF}$ and LD will be continued.
Thanks for your attention