FYS4515: Final project, fall 2019

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ABSTRACT

Here we present the final project tasks for the FY4515 course, fall 2019. We will give you real data from experiments performed at the Oslo Cyclotron Laboratory. You will analyze the data and present the results you obtain in a scientific report; you are very welcome to use this document as a template (in LaTeX). The master students will work in pairs on a given data set and can hand in a common report, while the PhD students will get their own data set. Of course, we encourage also the PhD students to work together, but they will need to hand in individual reports.

1 Introduction

In this course, the goal is to give you a theoretical introduction to reaction theory, as well as an introduction to nuclear structure and dynamics in the quasi-continuum region of atomic nuclei. As the Oslo method deals with nuclear properties in the quasi-continuum, we want to give you hands-on training on real-life data sets in various mass regions of the nuclear chart.

The Oslo method is a set of techniques and methods to, in the end, obtain the *nuclear level density* and the *γ-ray strength function* from a data set of particle-γ coincidences from inelastic-scattering reactions or transfer reactions like (^{3}He,^{3}He$'\gamma$) and $(d,p\gamma)$. We have measured the charged ejectile with silicon detectors and the γ rays with CACTUS in coincidence (i.e., within a time window of some tens of nanoseconds after the charged particle) in an event-by-event mode. In this way, we can create excitation-energy tagged γ-ray spectra, and arrange them into a matrix. What we will give you is such a matrix, already calibrated and time gated. It will be your task to analyze your matrix with the Oslo-method software, and to interpret the results. All data sets have previously been analyzed and the results have been published, so you can get details about the experiments from the published articles and compare your results with the previous ones.

2 The data sets

Here we present the six data sets and who is assigned to analyze which data set. *Note: the discrete levels might need to be updated, please compare the* counting.dat *files with the most recent evaluation at* https://www.nndc.bnl.gov/nudat2/. The published level densities and γ-ray strength functions can be found at https://ocl.uio.no/compilation/. Other useful links: The Reference Input Parameter Library https://www-nds.iaea.org/RIPL-3/ and Mughabghab's Atlas of Neutron Resonances (requires UiO network connection): http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&bquery=SE+%26quot%3bAtlas+of+Neutron+Resonances%26quot%3b&type=1&site=ehost-live.

Case 1: ^{111}Cd – Shailendra Bhandari and Marianne Bjerke

This data set was first published in Ref.[1]. The target was a foil of ^{112}Cd and the selected reaction is ^{112}Cd(^{3}He,$\alpha\gamma$)^{111}Cd. You will find the matrix ex_eg_111Cd.m in MaMa format, and the known, discrete levels in the file counting.dat.

Case 2: ^{164}Dy – Thomas Dahl-Jacobsen and Fardous Reaz

This data set was first published in Refs.[2,3] and recently re-analyzed in Ref.[4]. The target was a foil of ^{164}Dy and the selected reaction is ^{164}Dy(^{3}He,^{3}He$'\gamma$)^{164}Dy. You will find the matrix ex_eg_164Dy.m in MaMa format, and the known, discrete levels in the file counting.dat.

Case 3: ^{233}Th – Tellef Storebakken and Julian Ersland Vevik

This data set was first published in Refs.[5–7]. The target was a foil of ^{232}Th and the selected reaction is ^{232}Th$(d,p\gamma)^{233}$Th. You will find the matrix ex_eg_233Th.m in MaMa format, and the known, discrete levels in the file counting.dat.

Case 4: ^{238}Np – Dorthea Gjestvang

This data set was first published in Refs.[8,9]. The target was a foil of ^{237}Np and the selected reaction is ^{237}Np$(d, p\gamma)^{238}$Np. You will find the matrix ex_eg_238Np.m in MaMa format, and the known, discrete levels in the file counting.dat. In addition to analyzing the data with the standard Oslo-method software, we ask you to also use the OMpy package and compare the results you obtain with the two software packages.

Case 5: ^{74}Ge – Vetle Wegner Ingeberg

This data set was first published in Ref.[10]. The target was a foil of ^{74}Ge and the selected reaction is ^{74}Ge(^{3}He,^{3}He$'\gamma$)^{74}Ge. You will find the matrix ex_eg_74Ge.m in MaMa format, and the known, discrete levels in the file counting.dat. In addition to analyzing the data with the standard Oslo-method software, we ask you to also use the OMpy package and compare the results you obtain with the two software packages.

Case 6: ^{117}Sn – Francesco Pogliano

This data set was first published in Ref.[11] and re-analyzed in Ref.[12]. The target was a foil of ^{117}Sn and the selected reaction is ^{117}Sn(^{3}He,^{3}He$'\gamma$)^{117}Sn. You will find the matrix ex_eg_117Sn.m in MaMa format, and the known, discrete levels in the file counting.dat. In addition to analyzing the data with the standard Oslo-method software, we ask you to also use the OMpy package and compare the results you obtain with the two software packages.

3 The structure of the report

The report should contain the following:

- a title
- a short abstract
- an introduction (motivation) section
- a section describing the data set and analysis
- a section discussing the results
- a wrap-up section (summary/conclusions/outlook)

Make sure to refer properly to work that has been done before and to papers describing the methods you are using, external data etc etc. The following plots **must** be included in the report:

- A figure of the raw, unfolded, and first-generation matrices
- The normalized level density
- The spin cutoff parameter
- The un-normalized transmission coefficient
- The normalized γ-ray strength function

Also, all parameters that you have used should be reported, such as the limits in the first-generation matrix for extracting the level density and γ-ray strength and the normalization parameters you have used.

4 Software

The Oslo-method software can be found at `https://github.com/oslocyclotronlab/oslo-method-software`. Here we use mainly the MaMa code together with the codes rhosigchi.f, counting.c and normalization.c, as well as a couple of Root scripts (CERN data anlysis tool). You can find and download Root at `https://root.cern.ch`. Moreover, the OMpy package can be found here: `https://github.com/oslocyclotronlab/ompy`. You are all welcome to test the OMpy software, and the PhD students are required to provide a comparison of the standard Oslo-method software results and the OMpy results.

Condition	n	p
A	5	0.10
B	10	0.01

Table 1. Legend. Example legend text.

Figure 1. Legend. Example legend text.

5 Some LaTeX stuff

Figures and tables can be referenced in LaTeX using the ref command, e.g. Figure 1 and Table 1. LaTeX formats citations and references automatically using the bibliography records in your .bib file. Examples of including a figure and a table in LaTeX are given here:

6 Deadline

The deadline for handing in the report is set to **Thursday, 8 Nov 2019, at 17:00 (5PM)**. You are to hand in the reports via Canvas **as a pdf file**.

References

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12. Toft, H. K. *et al.* Evolution of the pygmy dipole resonance in sn isotopes. *Phys. Rev. C* **83**, 044320, DOI: 10.1103/PhysRevC.83.044320 (2011).