

Status of the Atlas of Neutron Resonances

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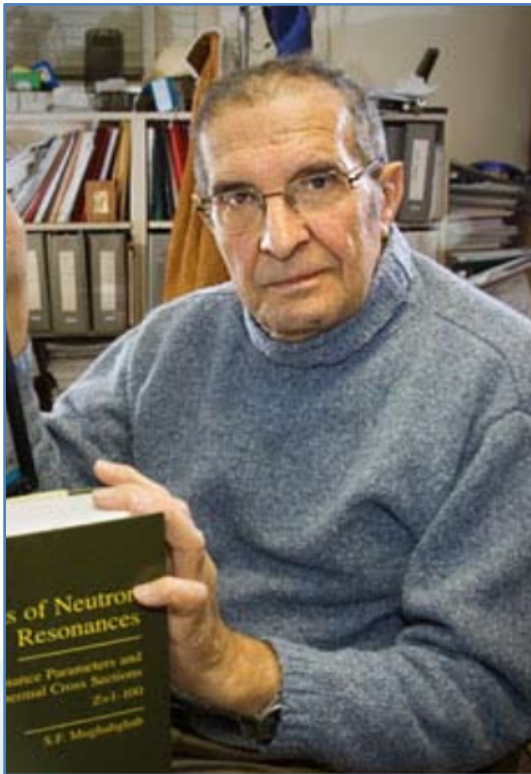
Brookhaven National Laboratory

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ENERGY

Atlas of Neutron Resonances

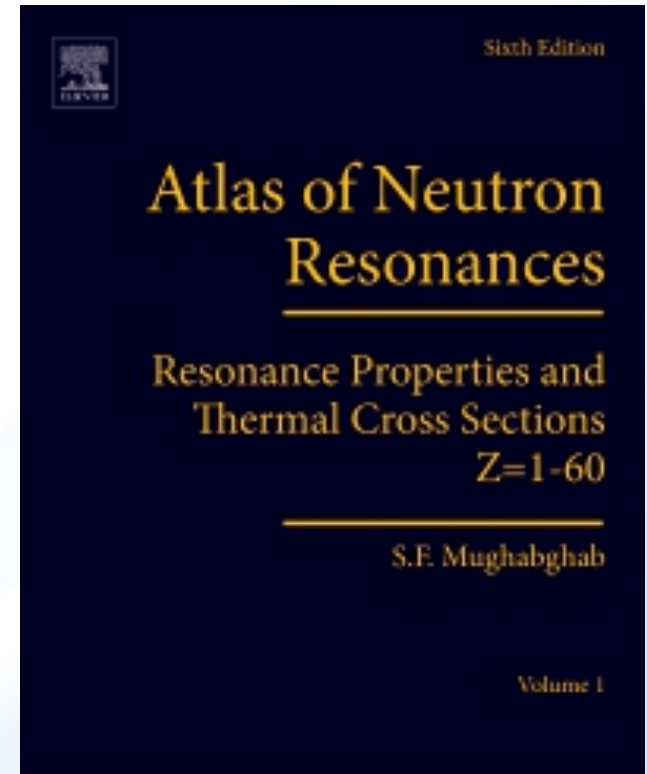
6th edition



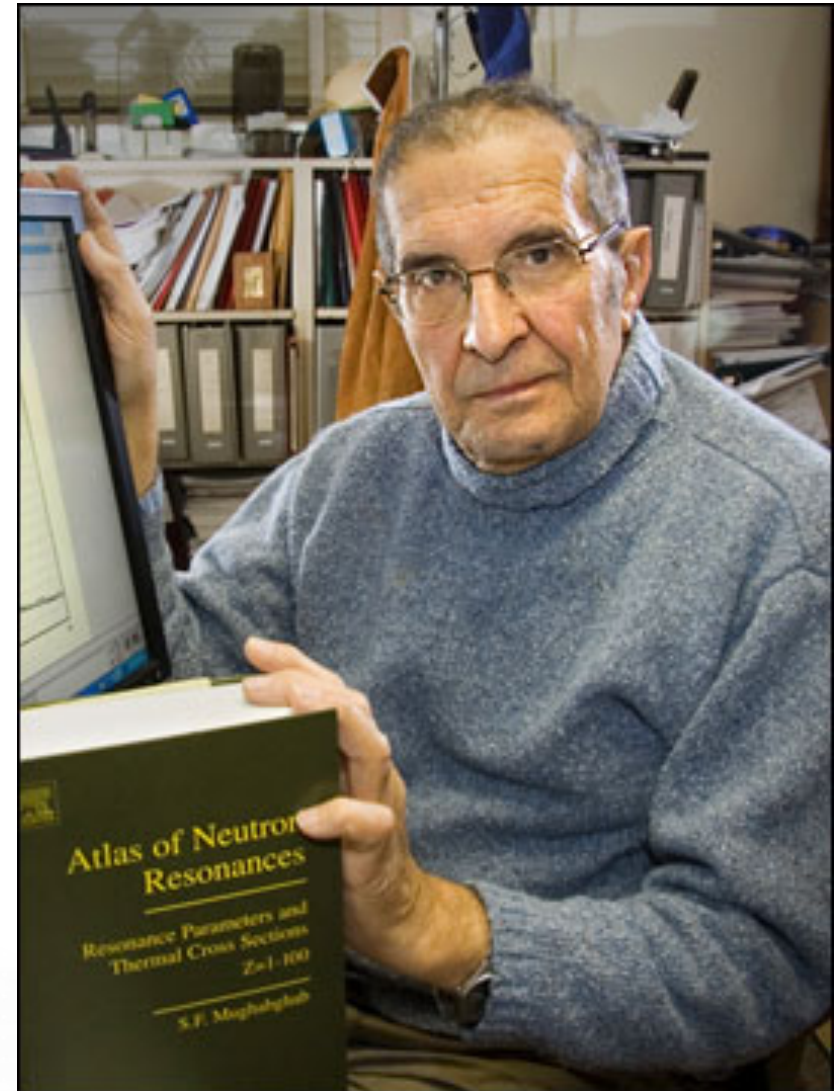
Said Mughabghab (BNL) passed on July 6, 2018.

We last saw him by the end of April when copies of the new Atlas arrived.

Said worked for more than 5 years on the new Atlas at no cost.



- While we are the inheritors of Said's work,
 - ***Elsevier owns the copyrights to the printed copy and the PDFs***
 - ***BNL (and therefore the US DOE) owns the electronic files***
- We are working to honor Said's life's work by preparing the electronic files for eventual release, but it will take time



What's happening now

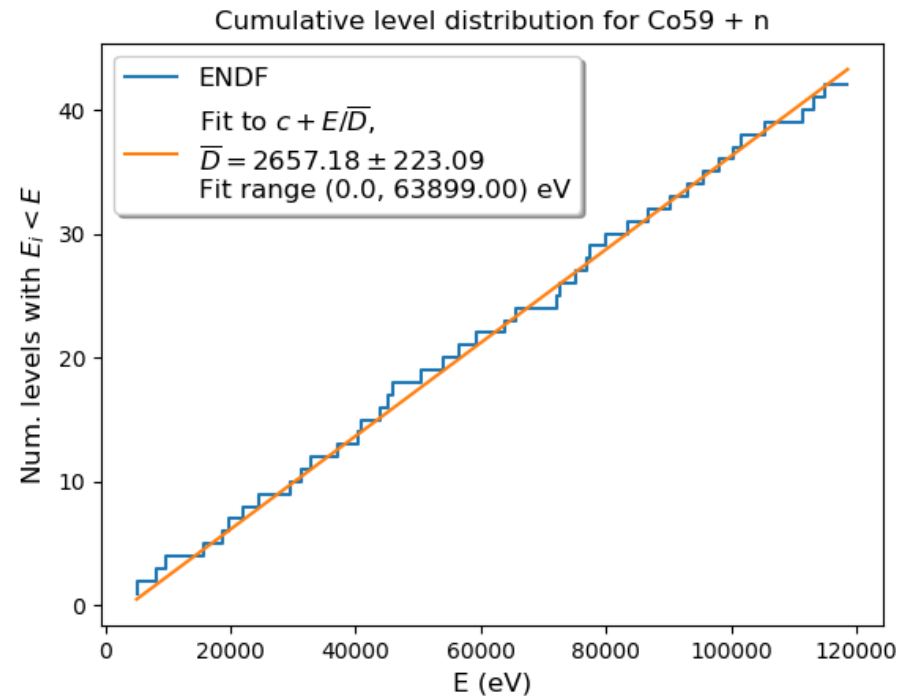
- **Clean up of the electronic files (SULI student G. Sayers)**
 - Many (most?) of changes made by Said were “hand edits” in a text editor
 - Careful analyses done in separate work area
 - Occasional typos, a bit of a treasure hunt
- **Careful documentation of the electronic files from which Atlas derived (SULI student G. Sayers)**
 - A pair of “punchcard-ready” formats deriving from original BNL-325 files
 - Atlas data tables are not done in LaTeX, it is translated directly into postscript
- **Developing Python API**

What we can expect soon (i.e., by CSEWG-ish)

- **Mean level spacing study (SULI student S. Hollick, see next slides)**
- **Atlas vs. EXFOR bibliography matching (SULI student G. Sayers)**
 - Note: NRDC performed earlier study done with older 2011 edition of Atlas and it was very informative
 - Atlas API connected to my x4i EXFOR API
 - Right now only checks is Atlas reference in EXFOR
 - Need to extend code to look for more recent references in EXFOR to update Atlas
 - Requires a human in the end since typos in both Atlas and EXFOR
 - Finished Cr isotopes:
 - Found 14 references in Atlas that have not made it to EXFOR
 - Found 1 Atlas typo

SULI Student S. Hollick is (re)developing tools to compute mean level spacing

- $D_{JLS} = \text{average}(E_n - E_{n-1})$ for given spin group (J,L,S)
- State of the art for today == state of the art in 1981:
 - Compute cumulative level distribution
 - Fit to straight line
 - Slope is $1/D$
- Can we do better?



Plot from grokres.py, part of FUDGE

The scheme

- Fit $CLD_{JLS}(E)$ to polynomial

$$CLD(E) = \sum_{i=0}^n c_i E^i$$

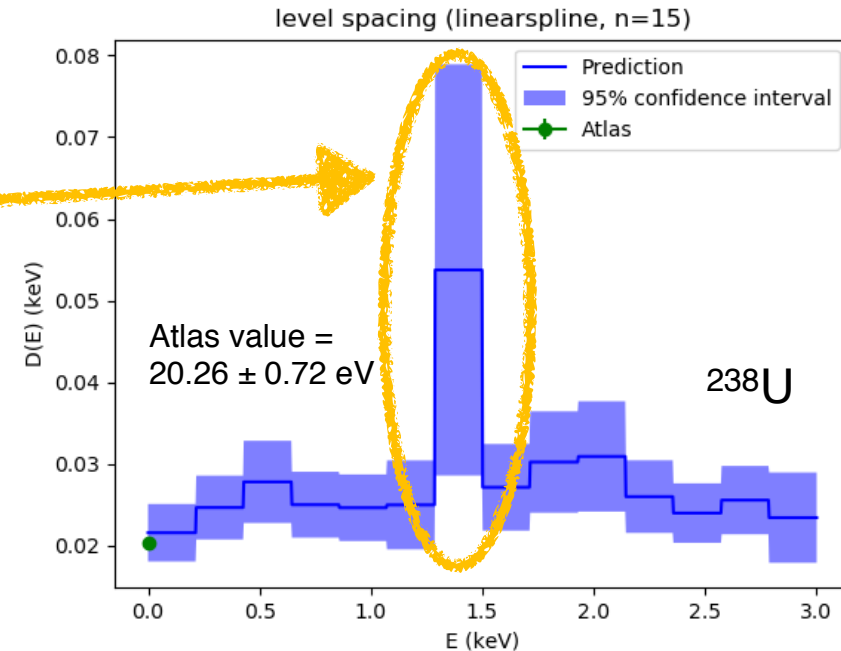
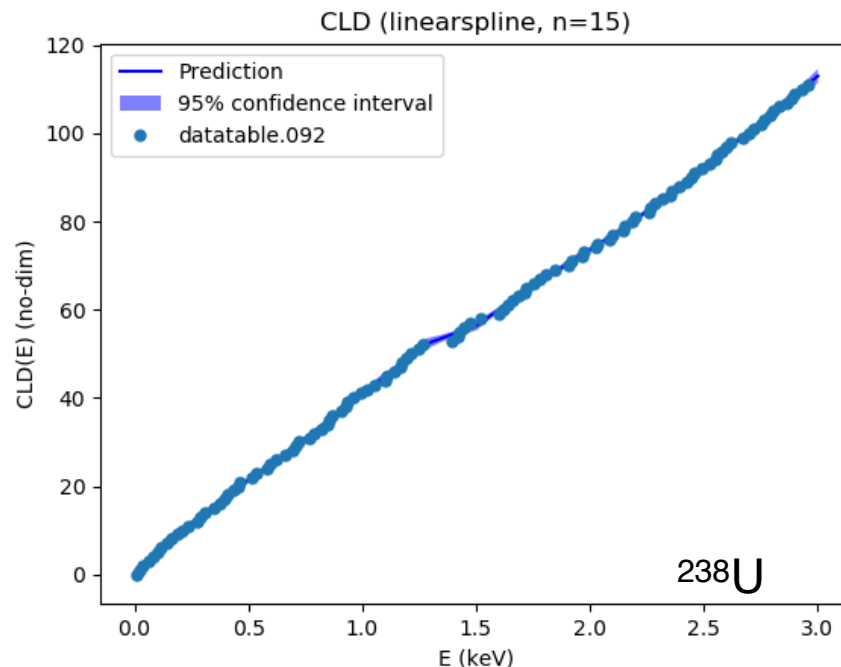
- Define spacing from inverse of 1st derivative:

$$D(E) \equiv [dCLD(E)/dE]^{-1}$$

- $D_{JLS}(E)$ should be approximately constant

- Bigger than average spacing => missing levels
- Less than average spacing => mislabeled levels

- Can compare to D_0 , D_1 from Atlas & from EXFOR



235U

- **Method clearly messed up, right?**

- Our's:

$$D_{3,0,1/2}=1.0 \text{ eV}$$

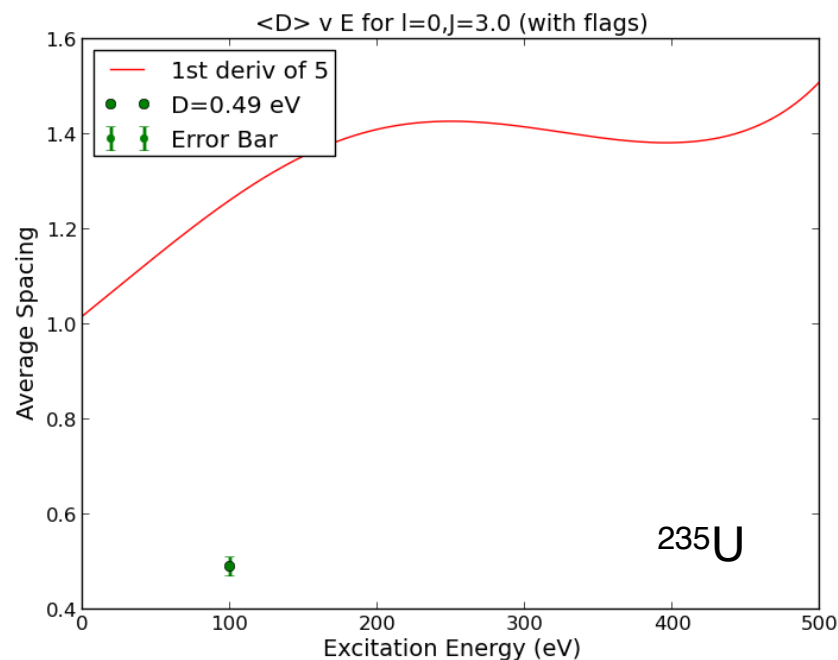
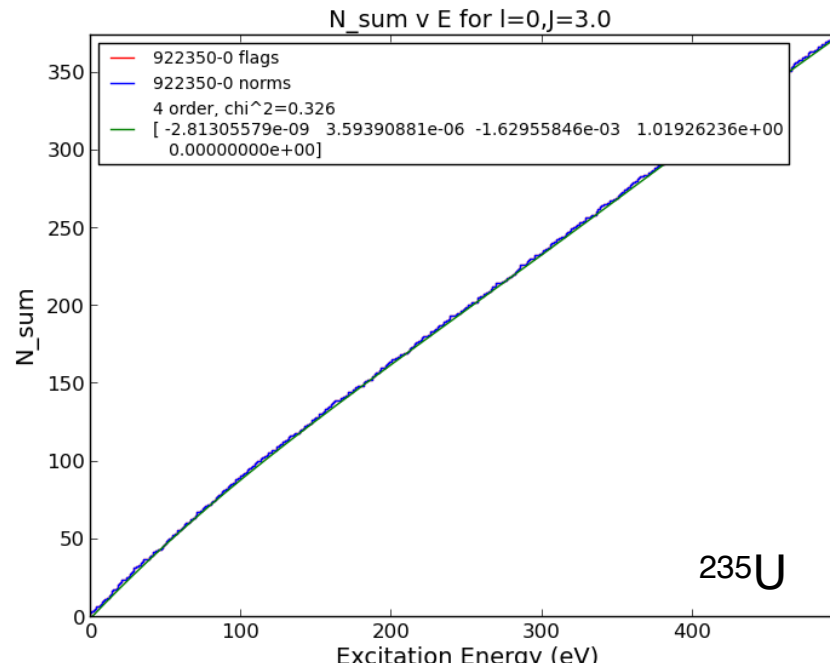
- Atlas:

$$D_0=0.49\pm 0.02 \text{ eV}$$

- **Importance of provenance!**

- ^{235}U has two sets of s-wave resonances, with $J=3,4$

- This fact is not stated in calculation of Atlas D_0



Medium term plans (1-2 years)

- **Extend API, implementing full FUDGE hooks**
 - This enables full suite of FUDGE's RRR diagnostics
 - Average widths, strength functions and all thermal values
 - Δ_3 statistic & many other GOE-related tests
 - Contingent of final electronic file cleanup and/or more fault tolerant parsing
- **URR analysis package**
 - Replace WRIURR in EMPIRE & Atlas
 - WRIURR assumes equal parity distribution, Gaussian spin distribution and essentially BSFG level density
 - Not careful in accounting for missing/mislabeled resonances
 - Builds off of already implemented FUDGE infrastructure
- **Implement covariances derived from Atlas**
 - Atlas contains capture resonance area & this is enough to generate meaningful covariances between elastic & capture
 - Energy-energy correlations also possible with simplistic model of resonance fitting process

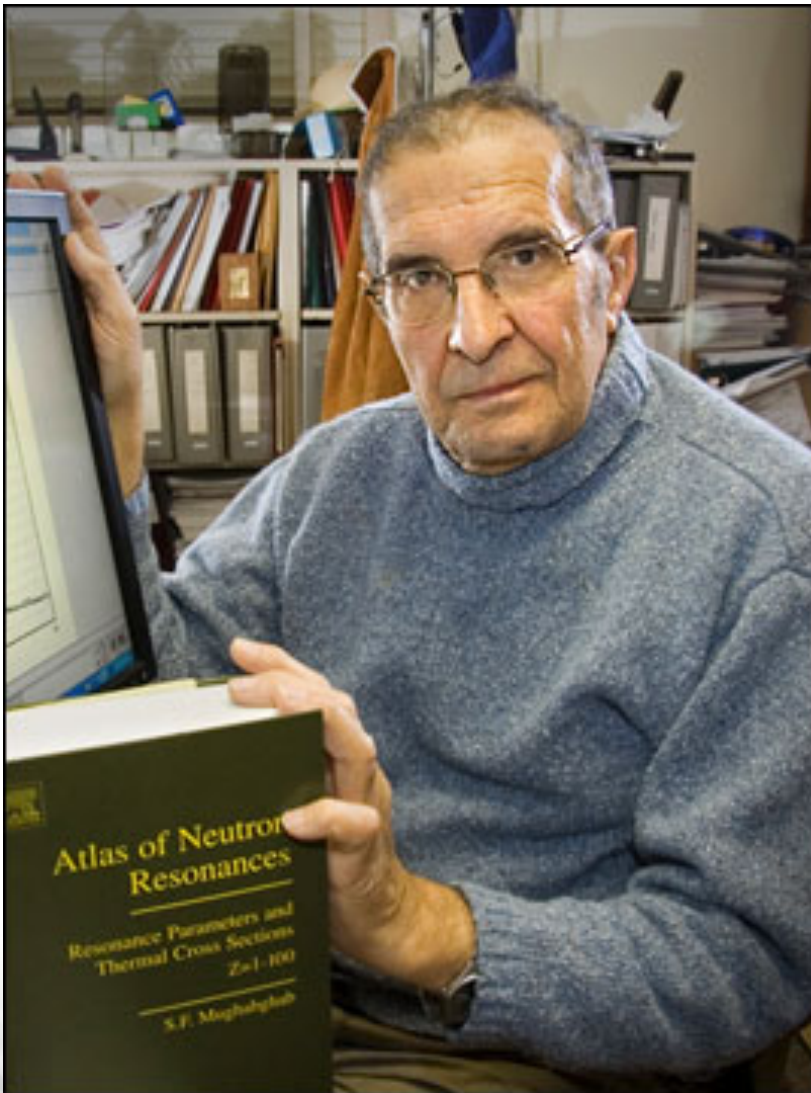
We intend to do as much of this as possible with students, this is an excellent set of projects for learning machine learning

Long term plans (3+ years)

- **Methods to establish provenance of all Atlas quantities**
 - Will likely require some combination of machine learning and SAMMY
 - The level spacing project is good practice
- **Automation to ensure currency with EXFOR**
- **Web portal**
- **Open source release**

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In memoriam Said Mughabghab (1934-2018)



**BS American University,
Lebanon, 1956.**

**MS, American University,
Lebanon, 1959.**

**PhD, University of
Pennsylvania, 1964.**

**BNL, Senior Scientist,
1963-2000.**

**BNL, Senior Scientist
Emeritus, 2008.**

Ref: <https://www.bnl.gov/newsroom/news.php?a=2483>