

# Isotope Effects in Thermal Neutron Scattering

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# Background

- AMPX links Thermal Scattering Law (TSL) libraries to isotopes in the resolved resonance region
  - TSL eval explicitly names isotope, we only bind TSL data to that isotope
    - tsl-013\_Al\_027, tsl-026\_Fe\_05
  - Otherwise, assumes all isotopes can apply the TSL eval
    - tsl-reactor-graphite-10P ->  $^{12}\text{C}$ -10p-graphite,  $^{13}\text{C}$ -10p-graphite
    - U-UO<sub>2</sub> ->  $^{233}\text{UO}_2 + ^{234}\text{UO}_2 + ^{235}\text{UO}_2 + \dots$
    - Zr-ZrH ->  $^{90}\text{ZrH} + ^{91}\text{ZrH} + ^{92}\text{ZrH} + \dots$
- No guidance is given in the TSL files or the ENDF format if this is acceptable or advised
- This can lead to some issues...

# Different Scattering Lengths

- Isotopes of the same element can have significantly different scattering lengths and, therefore, different bound/free scattering cross sections
- Element-specific bound/free scattering cross section given in File 7, but not sub-divided into isotopic distribution
- User must rely on either description in the ENDF file or references, which may not provide necessary description
- Different from issue in incoherent elastic bound scattering cross section issue (#13)

# Different Scattering Lengths – Comparison of Elemental and Isotopic Free Scattering Cross Sections

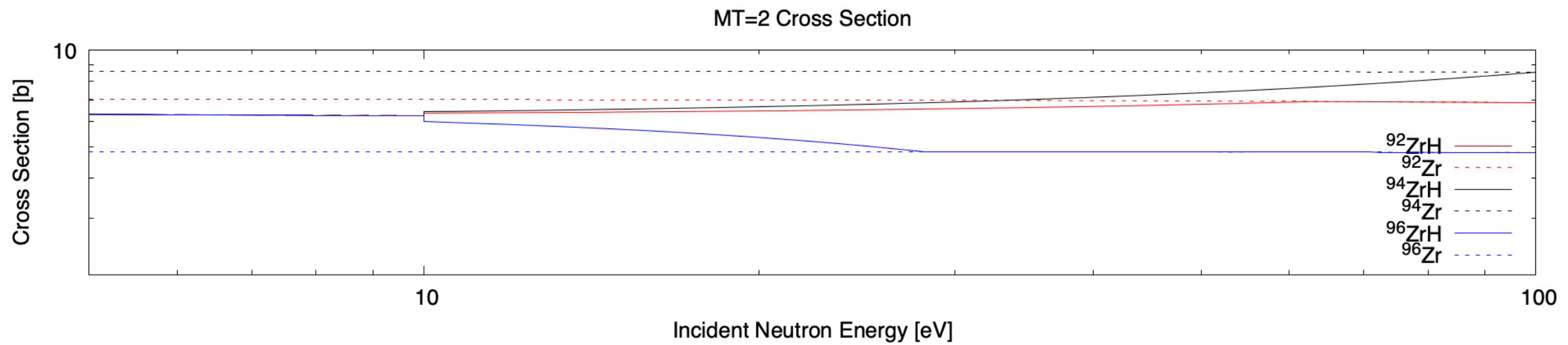
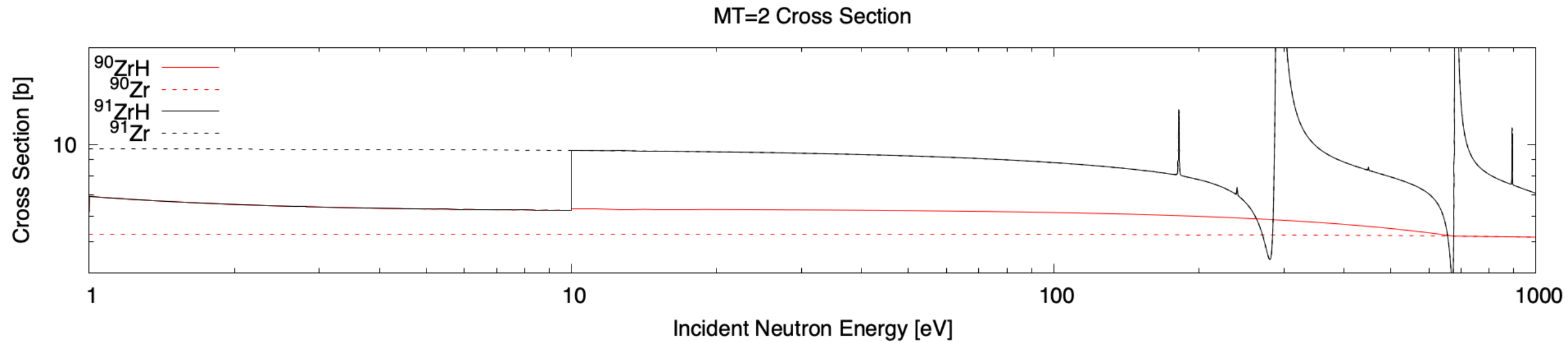
- Examples [1]:

Isotope/ Material	Weight pct.	Free Scattering xs [b]
<sup>90</sup> Zr	51.45	4.99
<sup>91</sup> Zr	11.32	9.49
<sup>92</sup> Zr	17.19	6.75
<sup>94</sup> Zr	17.28	8.22
<sup>96</sup> Zr	2.76	3.72
natZr		6.32
Zr-ZrH		6.34

Isotope/ Material	Weight pct.	Free Scattering xs [b]
<sup>28</sup> Si	92.23	1.98
<sup>29</sup> Si	4.67	2.60
<sup>30</sup> Si	3.1	2.47
natSi		2.02
Si-SiC		2.042

- Up to 50% difference between isotopic & elemental scattering XS

# Different Scattering Lengths

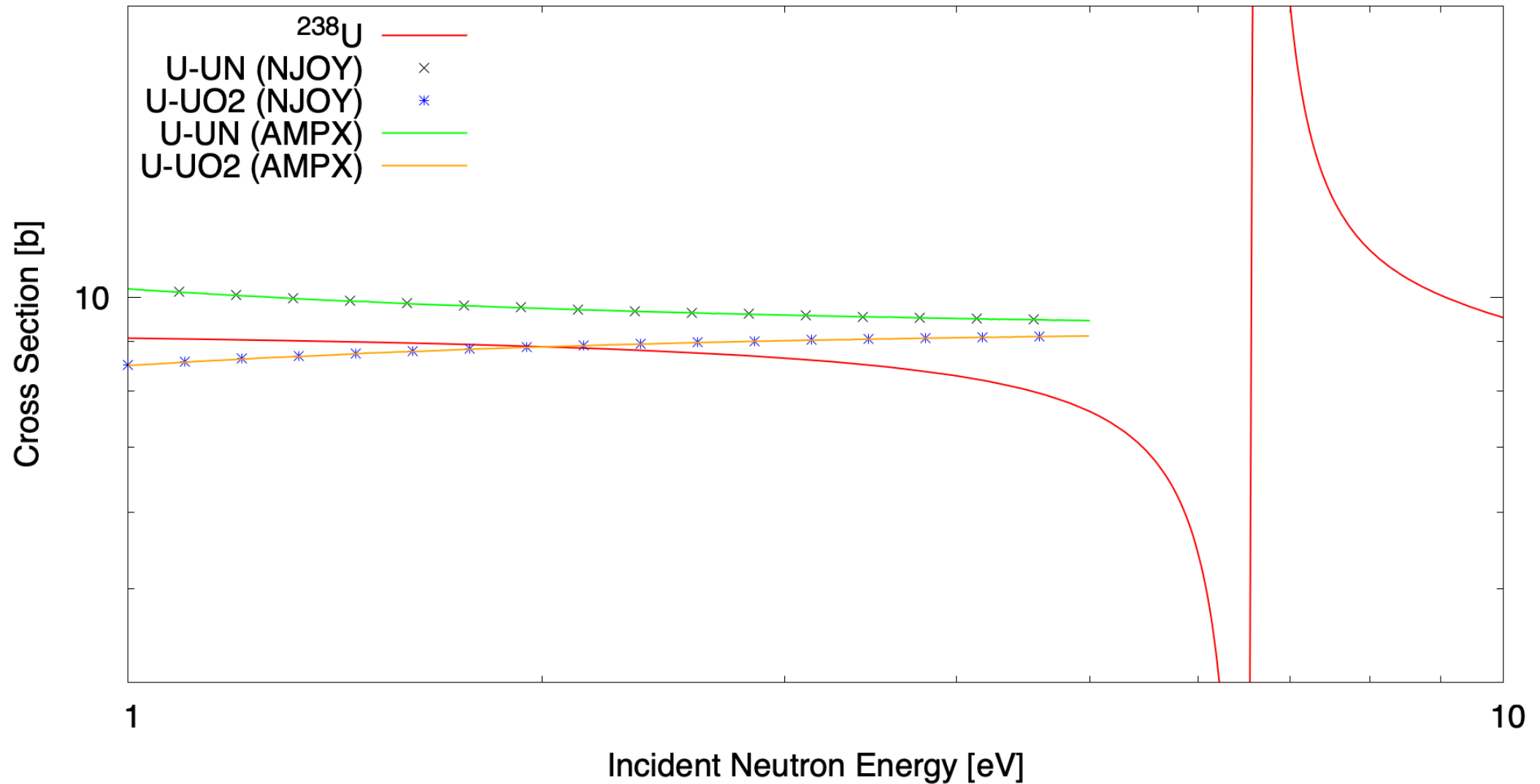


# Resonances

- Some isotopes have resonances near (or sometimes IN) the thermal range
- Resonance theory is not currently incorporated into thermal scattering evaluations
- These can have a noticeable effect on the thermal scattering cross section

# Resonances

MT=2 Cross Section - Uranium Fuels and  $^{238}\text{U}$



# Discussion

- Should information about the isotopic composition be provided in ENDF TSL files?
- Can anything be done regarding low-lying resonances?
  - Try and match the TSL cross section with the resonance at a specific cutoff energy (tricky, but doable)?
  - Implement resonances in thermal scattering (very difficult)?



# Acknowledgements

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# References

- [1] <https://www.ncnr.nist.gov/resources/n-lengths/>