

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}C -10p-graphite, ^{13}C -10p-graphite
 - U- UO_2 -> $^{233}\text{UO}_2$ + $^{234}\text{UO}_2$ + $^{235}\text{UO}_2$ + ...
 - Zr-ZrH -> ^{90}ZrH + ^{91}ZrH + ^{92}ZrH + ...
- 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

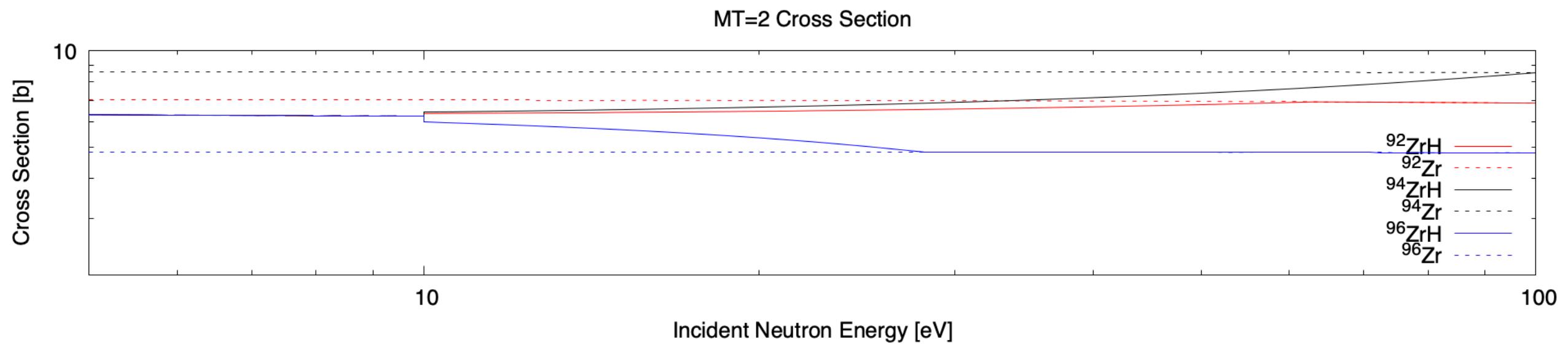
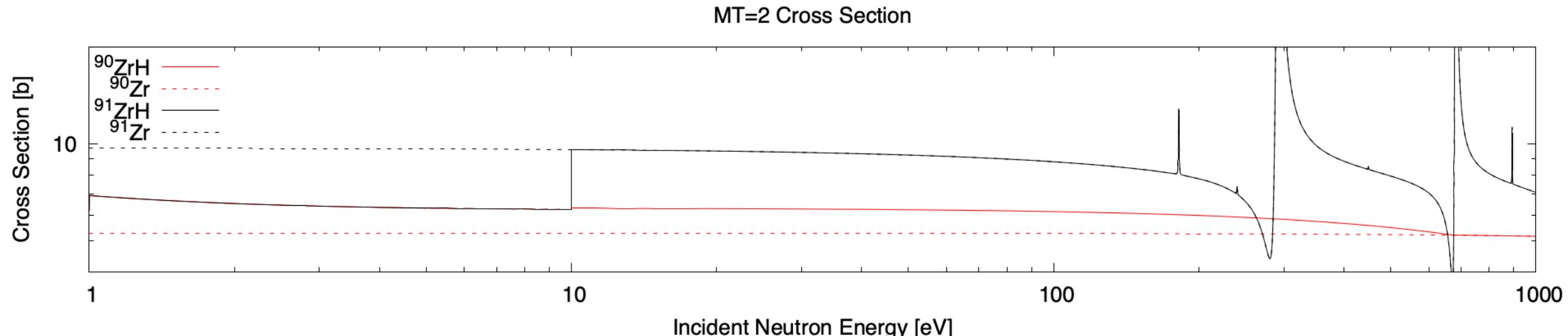
- Examples [1]:

Isotope/ Material	Weight pct.	Free Scattering xs [b]
^{90}Zr	51.45	4.99
^{91}Zr	11.32	9.49
^{92}Zr	17.19	6.75
^{94}Zr	17.28	8.22
^{96}Zr	2.76	3.72
$^{\text{nat}}\text{Zr}$		6.32
Zr-ZrH		6.34

Isotope/ Material	Weight pct.	Free Scattering xs [b]
^{28}Si	92.23	1.98
^{29}Si	4.67	2.60
^{30}Si	3.1	2.47
$^{\text{nat}}\text{Si}$		2.02
Si-SiC		2.042

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

Different Scattering Lengths

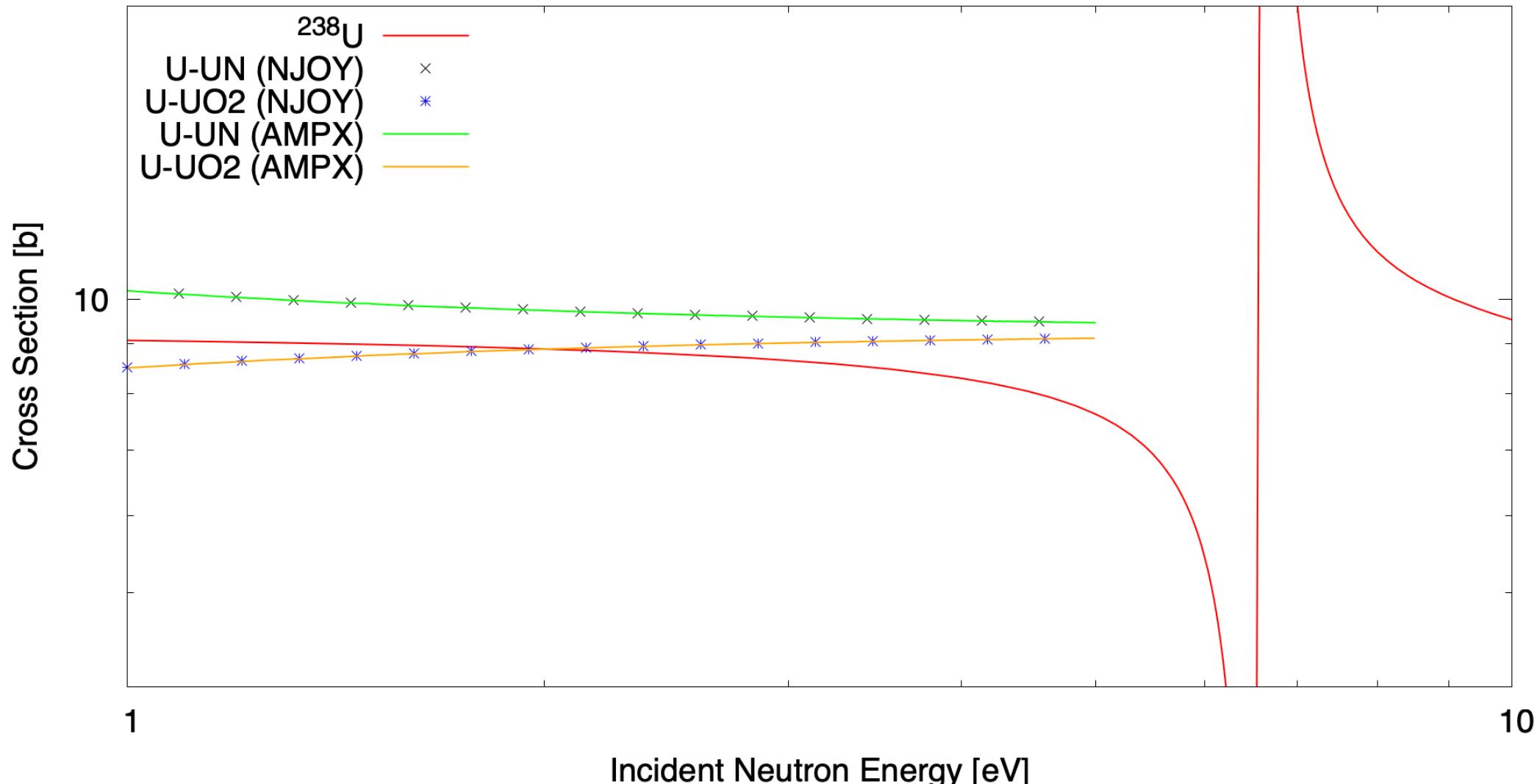


Resonances

- 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}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/>