Processing photo-nuclear and photo-atomic data in NJOY

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Photo-atomic and photo-nuclear data in ENDF

- Photo-atomic and photo-nuclear data have their own distinct sub-library
  - Photo-atomic data is given for elements (photons interact with the electron cloud)
  - Photo-nuclear data is given for nuclides (photons interact with the nucleus)
- ENDF files use distinctly different formats for these sub-libraries
  - Photo-atomic sub-library (NSUB=3)
    - MF23 for smooth cross sections
    - MF27 for coherent scattering form factors and incoherent scattering functions
    - MF26 for secondary particle distributions
  - Photo-nuclear sub-library (NSUB=0)
    - Essentially the same as incident neutron and incident charged particle sub-libraries
    - MF3 for cross section data
    - MF4-MF6 for secondary particle distribution data
    - MF31-MF40 for covariance data
Processing modules in NJOY2016

**Multigroup**
- Photo-atomic data
  - ENDF → RECONR → GAMINR → GENDF

**Multigroup**
- Photo-nuclear data
  - ENDF → RECONR → GROUPR → GENDF

**Continuous energy**
- Photo-atomic data
  - ENDF → RECONR → ACER → ACE → MCNP
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- Atomic relaxation data
  - This assumes MF23 data
  - Uses linearised data

**Continuous energy**
- Photo-nuclear data
  - ENDF → RECONR → ACER → ACE → MCNP
Photo-atomic and photo-nuclear ACE libraries

• Official ACE libraries for MCNP: https://nucleardata.lanl.gov

• Photo-atomic libraries
  – Multiple photo-atomic libraries have been released since 1982
  – Most recent version: MCPLIB63 and MCPLIB84 released in 2012

• Photo-nuclear libraries
  – Only one official library available: LA150U released in 2000 and updated in 2001
  – For a limited number of nuclides only (H2, C12, W184, Pb, etc.)

• Our long term goal: a new photo-nuclear ACE library based on ENDF/B-VIII.1
  – Work on improving processing (NJOY2016.64 and 2016.66)
  – Work on adding the photo-nuclear format to the ACE format specifications
  – Work on verification and validation for such a new library
Recent work on photo-nuclear data processing

• Traditional photo-nuclear data
  – Secondary photon distributions traditionally given using the LAW=1 LANG=1 format
  – Traditionally using a single Legendre coefficient (i.e. isotropic distribution)
  – This assumption was hardcoded in NJOY2016’s ACER module

• And then the IAEA-2019 library was released (August 2020)
  – Secondary distributions are using anisotropic Legendre expansion

• A major update for photo-nuclear data processing: NJOY2016.66
  – Secondary photon distributions now translated into ACE LAW=61
  – Properly handle photo-fission neutron multiplicity data when MF6/MT18 is used

• Please note: only MCNP6.3 is capable of using the photonuclear ACE files produced by NJOY2016.66
Recent work on photo-nuclear data validation

• We need experimental data and benchmarks for validation
  – It requires demonstratable sensitivity to photo-nuclear interactions

• We are looking into data comparison for now
  – For example: compare ENDF/B-VIII.0 and the IAEA-2019 library
  – Tallying particle spectra outside a disk bombarded mono-energetic photon or electron beam

• We could use your input and help on this topic
Conclusions and questions

• Photo-atomic data processing is an established activity at LANL
  – Multiple libraries have been released over the last 40 years
  – Verification and validation has been limited though

• Photo-nuclear data processing is being actively worked on
  – We want to release a new photo-nuclear ACE data library based on ENDF/B-VIII.1
  – We have been updating NJOY2016 towards this goal

• We need to work on photo-atomic and photo-nuclear data validation
  – Comparing data libraries on simplified problems
  – Identify validation benchmarks and experimental data
  – If you work on this, we want to collaborate with you