CHAPTER 7: MCNP PHYSICS AND MATERIAL CROSS SECTIONS

7.1 Problem Type

The MODE card specifies the problem type; neutron-only (N), neutron-photon (NP), photon-only (P), photon-electron(PE), electron-only (E), or neutron-photon-electron (NPE). Note that an electron-only problem by nature is also an electron-photon problem. The PHYS card specifies the physical aspects of the problem. It sets an upper energy limit and energy cut-offs and controls the allowed photon and electron interactions. At other than room temperature, the TMP (free-gas temperature) and the THTME (thermal times) card are needed for neutrons.

7.2 Cross Sections

A number of cross-section libraries are available. Use of the default library is recommended; consult the code on the use of various libraries.
Each cell requires its own cross sections, specified by a material number. There are eight classes of nuclear data tables for use in MCNP:

Neutron continuous energy: point-wise cross sections, for all reactions, together with angular distributions (and energy distribution for inelastic

scattering) and the average number of neutrons per fission for fissionable isotopes; as well as the atomic weight and the Q-value for each reaction .

Neutron discrete reaction: reaction cross sections are averaged (flat-weighted) into 262 energy groups; useful if computer storage is limited or for use with trace quantities of isotopes, but not recommended when dealing with resonance. Angular distributions, energy distributions, etc. are not averaged here.

Neutron dosimetry: used as a response function for the dose calculation tally.

Thermal neutrons (< 4 eV): optional but essential for thermalization problems.

Photon: (atomic), a logarithmic energy grid is given, including the photoelectric edges and the pair-production threshold. Tables of coherent and incoherent form factors are tabulated as a function of moment transfer. The logarithms of photoelectric, incoherent, coherent and pair productions are given, as well as the photon heating numbers. Angular distribution are isotropic for the photoelectric effect, fluorescence and pair production, while Thomson and Klein-Nishina formulas are used for coherent and incoherent scattering.

Electron: (atomic) bremsstrahlung production and energy distribution, x-ray production, K-edge energies and fluorescent probabilities, electron stopping powers and ranges, angular deflections and energy-loss parameters.

Mulitgroup: optional for forward problems, but are the only libraries allowed in multigroup/adjoint problems.

The main card is the material card, Mm, with m corresponding to the material number in the cell card. It assigns the isotopic composition of the material in the cell. Each isotope and its cross-section library are identified, together with its atomic or weight fraction in the mixture. Some other optional keywords are available with the Mm card, for more specific cross section information consult the manual.

The DRXS card can be used to enforce a discrete energy treatment of the neutron cross section of a designated, or all, isotopes.

The TOTNU (total fission card) provides control over the use of total (prompt and delayed) verses prompt-only fission neutrons. Fission in any cell can be turned-off with the NONU card.

Atomic weight ratios can be designated, if not available, via the AWTAB card. Note that the VOID card can be used to selectively void cells, without replacing the atomic number and density in the cell card; to for example examine the effect of a particular cell on the solution.

The MTm material card can used to associate an isotope to a particular thermal-treatment data if a cross-section data different from that used in the Mm card.

MCNP uses a data directory file, XSDIR, to find data tables for each isotope. Cross-sections not listed in this directly can be located using the XSm card. Multigroup calculations, forward or adjoint, require the use of the MGOPT card.

7.3 Work Problems

Explain each parameter in the following cards:

1. M1 NLIB=50D 1001 2 8016.50 C 1 6012 1
2. MGOPT F 12 $MODE P
3. VOID 3
4. M1 1001 2 8016 1
   MT1 LWTR.07