OpenMC Workshop

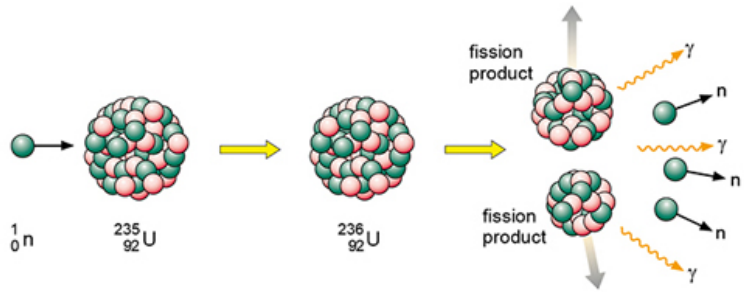
Depletion Briefer

ANS Student Conference

April 13, 2023

Depletion

- What happens when you turn the reactor on? Atoms split; short-lived products decay.
- We calculate k over time producing power
- Lets us know nuclide inventories, can calculate critical boron concentration, etc.



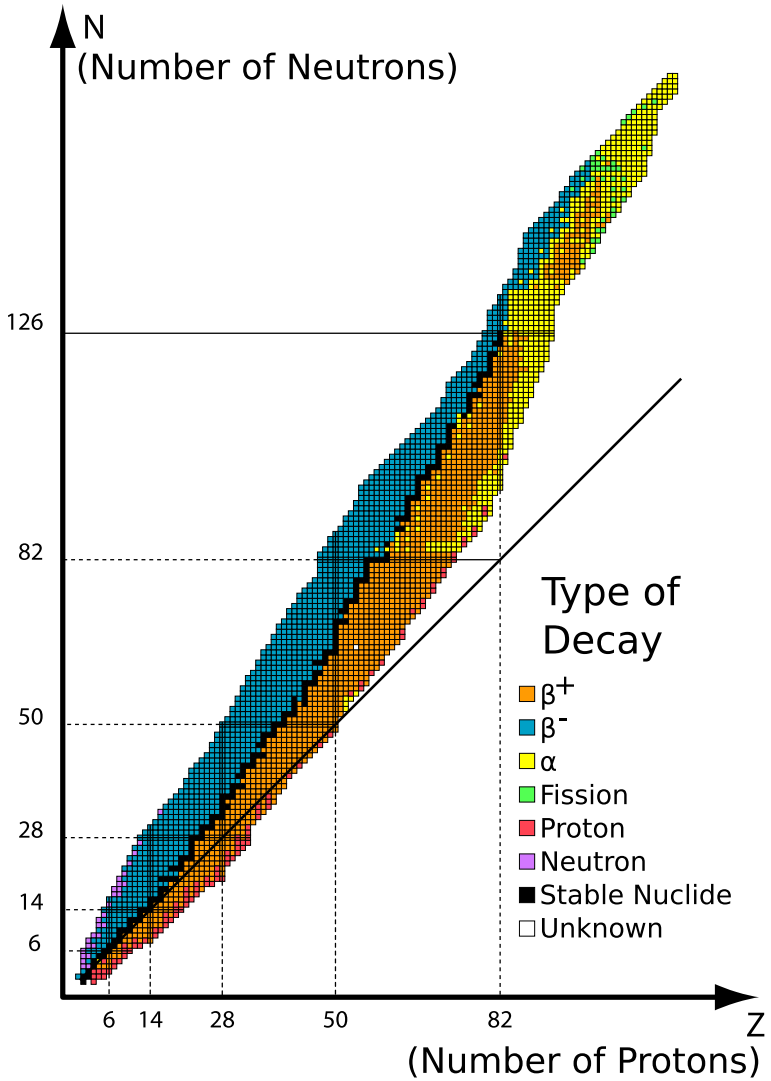


Image (L): https://www.open.edu/openlearn/mod/oucontent/view.php?id=26801&section=3.3

Image (R): https://commons.wikimedia.org/wiki/File:Table_isotopes_en.svg

Depletion

$$\frac{dN_i(t)}{dt} = \sum_j \underbrace{\left[\underbrace{f_{j\to i}\int_0^\infty dE\ \sigma_j(E,t)\phi(E,t)}_{\text{nuclear reactions}} + \underbrace{\lambda_{j\to i}}_{\text{decay}}\right] N_j(t)}_{\text{Production of nuclide } i \text{ from nuclide } j}$$

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OpenMC calculates the integrals involving flux!

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Depletion as a system of ODEs

$$\frac{d\mathbf{n}}{dt} = \mathbf{A}(\mathbf{n}, t)\mathbf{n}, \quad \mathbf{n}(0) = \mathbf{n}_0$$

where

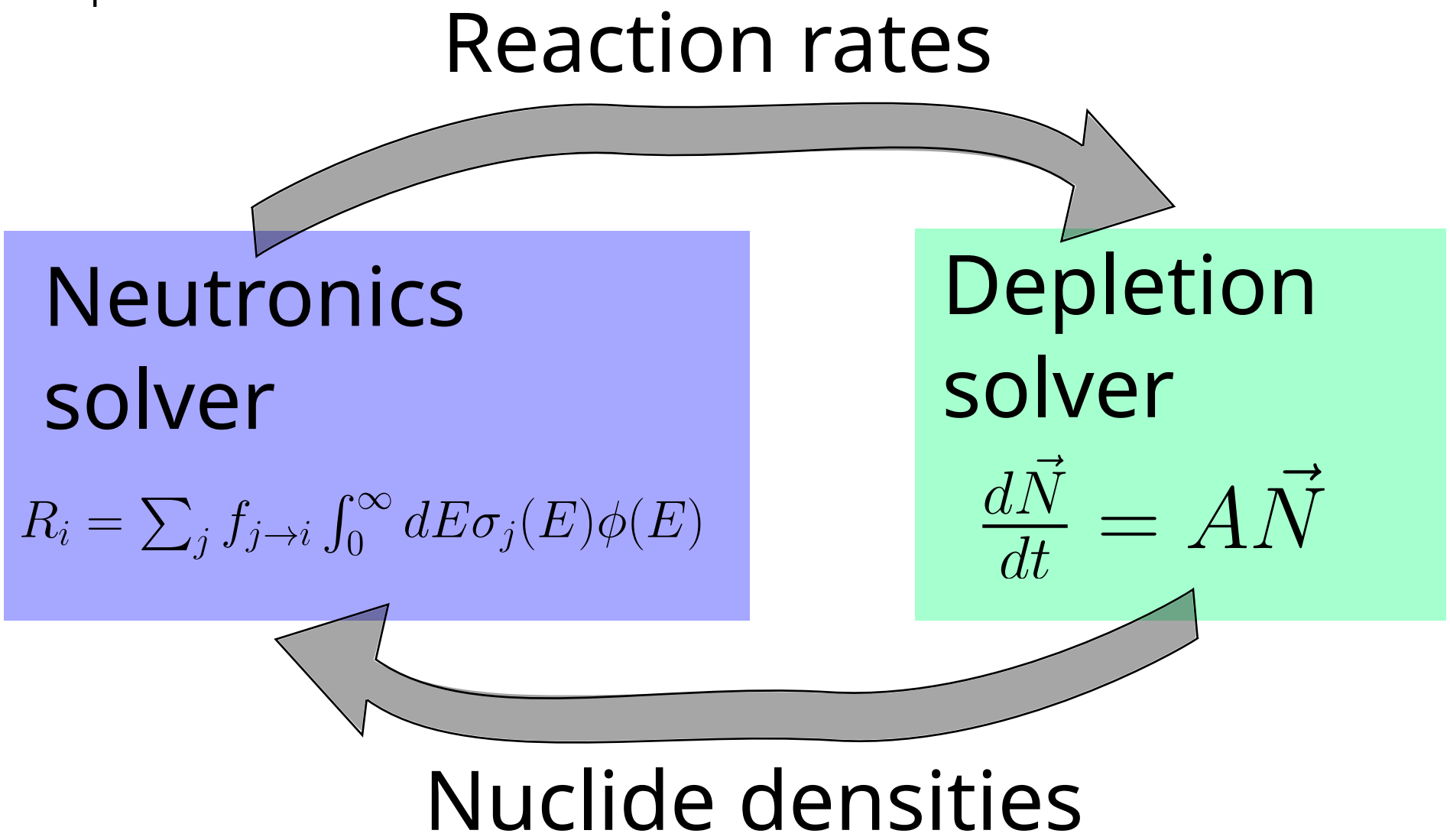
$$\mathbf{n} = \begin{pmatrix} N_1 \\ N_2 \\ \vdots \\ N_n \end{pmatrix}, \quad \mathbf{n}_0 = \begin{pmatrix} N_{1,0} \\ N_{2,0} \\ \vdots \\ N_{n,0} \end{pmatrix}$$

Since transport solution only depends on time on via $\mathbf{n}$, we can write

$$\frac{d\mathbf{n}}{dt} = \mathbf{A}(\mathbf{n})\mathbf{n}$$

Predictor method

The simplest integration method is known as the "predictor" method or constant extrapolation.



Further information

- OpenMC gives you a wide choice of integrators with tradeoffs in accuracy, computational cost, and memory requirements
- For more information on the theoretical background of depletion and comparisons of OpenMC with Serpent, see the journal paper by Romano et al.