



How do radioactive atoms “know” when to decay? If two atoms of uranium are identical, why will one of them decay now, and the other wait until later?

Wow! Let me begin by pointing out that the half-life of ^{238}U is about 4.5 billion years. That means that each of your two atoms has a 50% chance of decaying in any four and a half billion years. If one decayed today, maybe you should be buying lottery tickets.

Radioactive decay is subject to probabilistic operations, and predictions depend on large populations of nuclei. If you have very many atoms of uranium, then it is highly likely that in 4.5 BY you will have excruciatingly close to half as many. There is no way to predict when a particular (pun) nucleus is going to decay.

A nucleus consists of protons and neutrons held together by powerful forces. Certain combinations are more stable than others, it has to do with ratios and 'gluons' but I will avoid that. Within one element, and to be careful, let's assume we are talking about one nuclide, or one isotope of one element, so every atom has exactly the same combination of protons and neutrons, it would appear that all the nuclei are identical. But the particles have some combination of jiggles inherent in them, like siblings in the back seat of a car.

For a nuclide with a long half-life, most of the time the total jiggling stays inside the limit of the nucleus' binding force holding it together. It doesn't break apart. Every once in a long while, however, the jiggles might line up or form a resonance that sends the nucleus across the limit of its cohesion, and it will split.

A nuclide with a shorter half-life (less stable) will violate its binding energy sooner on a statistical basis. A stable nuclide will never violate its binding energy by itself.



Another way to visualize this: Imagine we are walking carrying a pail of water. If the pail is nearly empty, it is stable and water will not slosh out. If it is full to the brim, it is completely unstable and some water is certain to slosh out. In between is a gray

area where it may or may not slosh on any given step, and if we are not paying attention, we will not know when we are going to get our shoes wet.

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