## The Absorption of Light

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## **Main Article**

Electromagnetic radiation, or light, can be absorbed by most structures. The wavelength absorbed by a particular structure is proportionate to the size of a structure. Long wave radiation, millimeters or longer, are routinely absorbed by radio antennae of appropriate lengths. Smaller wavelength radiation is absorbed by smaller structures. Visible light is easily absorbed by typical size atoms. These have diameters of tens of thousands to millions of femtometers. The individual photons of light are absorbed by an entire electron orbit. High energy photons, with short wavelengths, are absorbed by electrons orbiting close to the nucleus.

A photon can only be absorbed if its size is similar to the size of the structure absorbing it. A photons diameter is its wavelength over pi. A structure from half to twice the diameter of the photon in diameter can potentially absorb the photon, with an exact match having the best absorption rate. For an electron orbiting a nucleus, an exact match just liberates the electron from orbit. A larger photon may promote the electron to a higher orbit, while a smaller photon will eject the electron with significant velocity.

The highest energy photon an atom will absorb occurs when the final 1s electron catches a photon half the diameter of its orbit. Orbital radius in this case is Bohr's radius over the charge on the nucleus. For Hydrogen (element 1), this is about 52,900 fm. For element 100 (Fermium) the radius is about 529 fm. The top energy varies from 27 eV to .27 MeV.

Higher energy photons can be absorbed by smaller structures. An electron has a radius of 386 fm, so it can absorb photons with 255 KeV through 1020 KeV. This results in electrons leaving the vicinity of impact at a large fraction of the speed of light. Below the size of an electron, the next known range of structures is the atomic nuclei. Here, the smallest nucleus (the neutron) is just larger than a femtometer in diameter, while the largest are under 20 fm. These can absorb photons of hundreds of MeV down through 8. There is an interesting gap between the absorption of 1 MeV by an electron and 8 MeV by a heavy nucleus. From some theories, dark matter can absorb photons in this range (and no other).

If the goal is the absorption of a large fraction of high energy photons (gamma rays), the typical technique is a thick slab of Lead. The inner orbit (1s) electrons absorb "soft" gamma rays fairly effectively (under 100 KeV), and the free electrons absorb medium energy gamma rays effectively. The absorption in the 180-260 KeV range is poor, as is the absorption of "hard" gamma (above 1 MeV).

Adding depleted Uranium to the Lead is some help, absorbing better in the 180-230 KeV range than lead (since it's last 1s electron is 115 KeV, compared to 91 KeV for Lead), but it does little better on hard gamma. It should not be assumed the absorption is zero, but the rate of absorption is generally treated as normal ( $e^{-x^2}$ ) to the log of energy relative to the peak rate of absorption. So at a half (or twice) the peak point of energy absorption, actual absorption is less than 10% the peak rate, and at a quarter the energy causing the peak absorption it is less than 1%. Multiplying this low absorption rate by trillions of opportunities, the gamma rays are eventually absorbed. If a technique for adding significant supplies of dark matter were available, the problem could be solved.