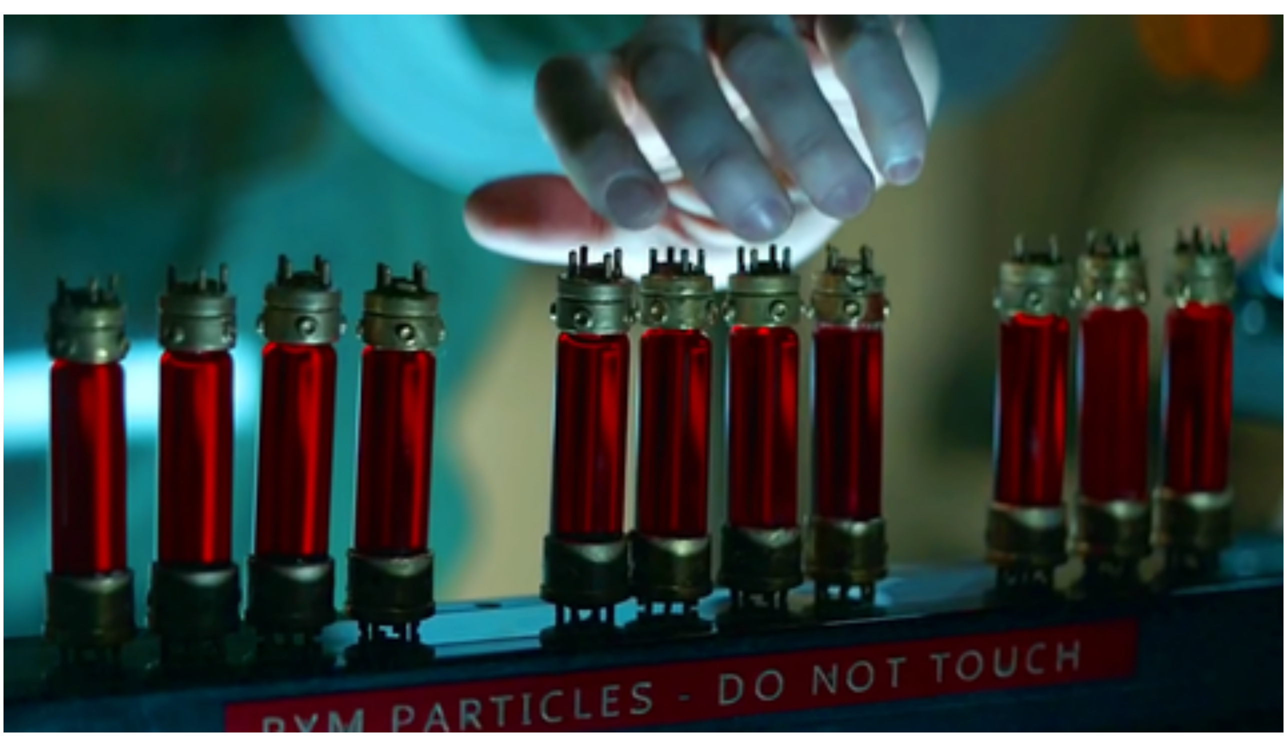
The Science(-Fiction) of Ant-Man

We Talk Physics

Marvel Studios/Walt Disney Studios Motion Pictures

In the 2015 Marvel film *Ant-Man*, there is the concept of a suit which allows its user to shrink down to a miniscule size. What is the science (fiction) behind this?

In real life, shrinking down to such small sizes would have many problems due to how the physics of your body works. If a human were to be shrunk down in size while maintaining the same mass, then the tiny human's density would be incredibly high — it would be comparable to the density of white dwarf stars! On the other hand, if the human's mass shrunk proportionally, then they would end up weighing very little! Even a light breeze would be enough to blow the human away. On top of all this, the simple principle known as the square-cube law describes the relationship between the volume and the surface area of an object — as an object shrinks, its surface area is decreased less than its volume is decreased. This means that the area of a small human's muscles and bones to their is very high relative to a larger human's, making them much stronger pound for pound.



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However, in *Ant-Man*, most of the "science" behind the shrinking technology revolves around the use of Pym particles, which are fictional subatomic particles discovered by the character Hank Pym in the 1960s. These particles can be used to increase the mass and volume of an object at will, avoiding all the problems that one would encounter in real life. Hank Pym uses these particles to create the Ant-Man suit, allowing him (and his successor, Scott Lang) to control the power of the particles and shrink themselves at will. However, there are limits to how small one can shrink even with Pym particles — go any smaller than an atom, and one will enter the fictional Quantum Realm, "a reality where all concepts of time and space become irrelevant."

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Despite Pym particles being fictional, Spiros Michalakis, science consultant for the film, suggests that one possible approach (we don't know how to do this yet!) would be to somehow convert all electrons into muons. Muons are particles usually associated with high-energy phenomena like cosmic rays, and are 200 times heavier than electrons but have the same charge. This would allow a human to shrink to a tiny size without changing any chemistry. However, muons have an incredibly short lifetime of just roughly two millionths of a second before they decay into electrons. There are ways of extending this lifetime by giving the muons more energy, but the amount that would be required to shrink for even a few seconds is — for now — far beyond what we are capable of producing.

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