

Fundamentals of Fundamental

What is "Fundamental"? In physics, as in any other context where this word is used, the answer is "it depends..." The word "fundamental" has several definitions with different meanings; therefore, using it in general and in physics in particular often hinders rather than helps clarify the subject of study since this vagueness may mislead, confuse and obfuscate the study and ultimate understanding of the subject in several ways: applying an unsuitable meaning of the word to the subject will needlessly complicate its already complex study; using different meanings of "fundamental" inadvertently at the same time in reasoning about the subject will result in logical mistakes that will lead just as inadvertently to mistaking the wrong conclusions as the correct ones; finally, none of the meanings of the word "fundamental" may apply to the subject of study leading to the common mistake of forcing together ideas that are (ironically!) fundamentally different and instead wasting endless effort and time unifying them "because they should be the same since they are fundamental!" even when these ideas are mutually and glaringly incompatible. Thus, using the word "fundamental" in these manners can and will prevent the understanding of the complex ideas of modern theoretical physics and ultimately a clear and precise understanding of our Universe and reality.

The word "fundamental" appears in many physical theories but even more so in the most recent ones. This is not a coincidence since the modern theories attempt to explain ever greater realms of the Universe and with the stated ultimate intent of describing, explaining and understanding reality itself. The belief that such goal is within human grasp has lead many researchers to pursue it by finding a so-called "theory of everything" (TOE for short) – a theory that should explain and predict all observations explained and predicted by all the disparate current theories with at least the same precision and accuracy. Because this TOE is by definition the core principle that explains all observed reality, it certainly can be called "fundamental" in this specific sense of the word; therefore, the motivation (and temptation) exists to say that various elements of competing TOE candidates are "fundamental": "fundamental particles", "fundamental interactions", "fundamental properties", "fundamental constants" and so on.

However, calling things "fundamental" can also mean that they are the basic elements of something and so that they are or should be "the same" in a real sense. Researchers have therefore spent enormous efforts in unifying the theories describing the four "fundamental" interactions or forces ever discovered. They have even been encouraged by coming up with theories that unify all interactions carried by particle exchange, but not gravity which is not a force according to the theory that best describes it.