It is an everyday fact of life that Nature comes to us with a variety of scales: from quarks, nuclei and atoms through planets, stars and galaxies up to the overall Universal large-scale structure. Science progresses because we can understand each of these on its own terms, and need not understand all scales at once. This is possible because of a basic fact of Nature: most of the details of small distance physics are irrelevant for the description of longer-distance phenomena. Our description of Nature’s laws uses quantum field theories, which share this property that short distances mostly decouple from larger ones. Effective Field Theories (EFTs) are the tools developed over the years to show why it does. These tools have immense practical value: knowing which scales are important and why the rest decouple allows hierarchies of scale to be used to simplify the description of many systems.

The world around us contains a cornucopia of length scales, ranging (at the time of writing) down to quarks and leptons at the smallest and up to the universe as a whole at the largest, with qualitatively new kinds of structures — nuclei, atoms, molecules, cells, organisms, mountains, asteroids, planets, stars, galaxies, voids, and so on — seemingly arising at every few decades of scales in between. So it is remarkable that all of this diversity seems to be described in all of its complexity by a few simple laws. How can this be possible? Even given that the simple laws exist, why should it be possible to winkle out an understanding of what goes on at one scale without having to understand everything all at once? The answer seems to be a very deep property of Nature called decoupling, which states that most (but not all) of the details of very small-distance phenomena tend to be largely irrelevant for the description of much larger systems. For example, not much need be known about the detailed properties of nuclei (apart from their mass and electrical charge, and perhaps a few of their multipole moments) in order to understand in detail the properties of electronic energy levels in atoms. Decoupling is a very good thing, since it means that the onion of knowledge can be peeled one layer at a time: our initial ignorance of nuclei need not impede our unravelling of atomic physics, just as ignorance about atoms does not stop working out the laws describing the motion of much larger things, like the behaviour of fluids or the motion of the moon. It happens that this property of decoupling is also displayed by the mathematics used to describe the laws of nature [1]. Since nowadays this description is done using quantum field theories, it is gratifying that these theories as a group tend to predict that short distances generically decouple from long distances, in much the same way as happens in Nature. This book describes the way this happens in detail, with two main purposes in mind. One purpose is to display decoupling for its own sake since this is satisfying in its own right, and leads to deep insights into what precisely is being accomplished when writing down physical laws. But the second purpose is very practical; the simplicity offered by a timely exploitation of decoupling can often be the difference between being able to solve a problem or not. When exploring the consequences of a particular theory for short distance physics it is obviously useful to be able to identify efficiently those observables that are most sensitive to the theory’s details and those from which they decouple. As a consequence, the mathematical tools — effective field theories — for exploiting decoupling have become ubiquitous in some areas of theoretical physics, and are likely to become more common in many more.

In [fisica](https://it.wikipedia.org/wiki/Fisica) una **teoria di campo efficace** è un tipo di approssimazione, o teoria efficace di una teoria fisica sottostante, come la [teoria quantistica dei campi](https://it.wikipedia.org/wiki/Teoria_quantistica_dei_campi) o un modello della [meccanica statistica](https://it.wikipedia.org/wiki/Meccanica_statistica). Una teoria dei campi efficace include i [gradi di libertà](https://it.wikipedia.org/wiki/Grado_di_libert%C3%A0_(termodinamica)) utili a descrivere i fenomeni fisici che si verificano ad una determinata [scala di lunghezza](https://it.wikipedia.org/wiki/Scala_di_lunghezza) o scala di energia, ignorando la sottostruttura e i gradi di libertà a distanze inferiori (o equivalentemente a energie più elevate). Intuitivamente, si trascurano gli effetti delle scale di lunghezza inferiore (integrando sui relativi gradi di libertà) della teoria sottostante per derivare quello che si spera essere un modello semplificato valido per le scale di lunghezza d'interesse. Le teorie di campo efficaci in genere funzionano meglio quando c'è una grande separazione tra la scala di lunghezza di osservazione e la scala di lunghezza delle dinamiche sottostanti. Le teorie di campo efficaci vengono tipicamente usate nella [fisica delle particelle](https://it.wikipedia.org/wiki/Fisica_delle_particelle), nella [meccanica statistica](https://it.wikipedia.org/wiki/Meccanica_statistica), nella [fisica dello stato solido](https://it.wikipedia.org/wiki/Fisica_dello_stato_solido), nella [relatività generale](https://it.wikipedia.org/wiki/Relativit%C3%A0_generale) e nell'[idrodinamica](https://it.wikipedia.org/wiki/Idrodinamica). Il loro utilizzo in genere semplifica i calcoli e permette di trattare gli effetti della [dissipazione](https://it.wikipedia.org/wiki/Struttura_dissipativa) e della [radiazione](https://it.wikipedia.org/wiki/Radiazione).

Un famoso esempio è la [teoria della superconduttività BCS](https://it.wikipedia.org/wiki/Teoria_BCS). Qui la teoria sottostante è la teoria degli [elettroni](https://it.wikipedia.org/wiki/Elettrone) in un [metallo](https://it.wikipedia.org/wiki/Metallo) che interagiscono con vibrazioni reticolari chiamate [fononi](https://it.wikipedia.org/wiki/Fonone). I fononi causano interazioni attrattive tra alcuni elettroni, inducendoli a formare [coppie di Cooper](https://it.wikipedia.org/wiki/Coppia_di_Cooper). La scala di lunghezza di queste coppie è molto più grande rispetto alla lunghezza d'onda dei fononi, rendendo possibile trascurare la dinamica dei fononi e costruire una teoria in cui due elettroni interagiscono efficacemente in un punto. Questa teoria ha avuto un notevole successo nel descrivere e prevedere i risultati degli esperimenti sulla superconduttività.