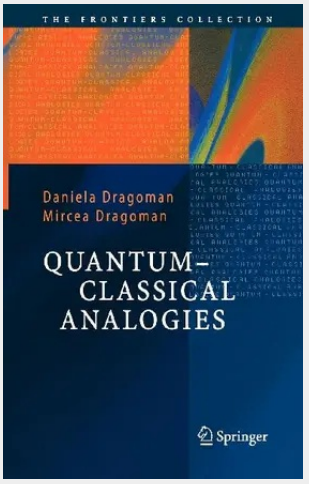
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Quantum-Classical Analogies



It is unanimously accepted that the quantum and the classical descriptions of the physical reality are very different, although any quantum process is "mysteriously" transformed through measurement into an observable classical event. Beyond the conceptual differences, quantum and classical physics have a lot in common. And, more important, there are classical and quantum phenomena that are similar although they occur in completely different contexts. For example, the Schrödinger equation has the same mathematical form as the Helmholtz equation, there is an uncertainty relation in optics very similar to that in quantum mechanics, and so on; the list of examples is very long. Quantum-classical analogies have been used in recent years to study many quantum laws or phenomena at the macroscopic scale, to design and simulate mesoscopic devices at the macroscopic scale, to implement quantum computer algorithms with classical means, etc. On the other hand, the new forms of light – localized light, frozen light – seem to have more in common with solid state physics than with classical optics. So these analogies are a valuable tool in the quest to understand quantum phenomena and in the search for new (quantum or classical) applications, especially in the area of quantum devices and computing.

Although quantum and classical physics are founded on very different principles, similarities between quantum and classical phenomena are not uncommon. This fact was considered by physicists as a mere curiosity until, quite recently, it became clear that such analogies between quantum and classical physics can be exploited in theoretical as well as experimental work in emerging key research areas. The analogies described in this book include the mathematical similarity between the Schrödinger equation and the Helmholtz equation (and its application in nanodevice design), the similarities between quantum multi-level systems and their optical counterparts, and the optical implementations of quantum computing algorithms. Also described are the mathematical analogies between classical and quantum phase space physics. These analogies help to deepen our understanding of stll hotly debated quantum mechanical principles

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