A single copy of an unknown quantum state cannot be cloned [W. K. Wootters and W. H. Zurek, Nature 299 (1982), 802–803]. This is an essential rule in quantum mechanics. However, the study of the so-called “quantum cloning machines” [V. Bužek and M. Hillery, Phys. Rev. A (3) 54 (1996), no. 3, 1844–1852; MR1450566 (98f:81026)], defined as unitary operations which perform the optimal approximate cloning allowed by quantum mechanics in a particular scenario, has become the subject of intense research. Quantum cloning machines are useful tools for studying a wide variety of tasks, e.g., quantum state estimation and the security of quantum key distribution. This paper provides a comprehensive review of quantum cloning machines, both for discrete and continuous quantum systems. In addition, it discusses the role of quantum cloning in quantum cryptography, the link between optimal cloning and light amplification by stimulated emission, several experimental demonstrations of quantum cloning machines, and also addresses some questions in this field which are still open.

Reviewed by Adán Cabello