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Autore	Leung Kon H
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Nota di contenuto	Chapter 1: Introduction -- Chapter 2: Molecular structure and production of ultracold $^{88}\text{Sr}_2$ in an optical lattice -- Chapter 3: Frequency comb assisted spectroscopy of the states -- Chapter 4: Ultracold $^{88}\text{Sr}_2$ molecules in the absolute ground state -- Chapter 5: Terahertz vibrational molecular clock.
Sommario/riassunto	This thesis describes how the rich internal degrees of freedom of molecules can be exploited to construct the first “clock” based on

ultracold molecules, rather than atoms. By holding the molecules in an optical lattice trap, the vibrational clock is engineered to have a high oscillation quality factor, facilitating the full characterization of frequency shifts affecting the clock at the hertz level. The prototypical vibrational molecular clock is shown to have a systematic fractional uncertainty at the 14th decimal place, matching the performance of the earliest optical atomic lattice clocks. As part of this effort, deeply bound strontium dimers are coherently created, and ultracold collisions of these Van der Waals molecules are studied for the first time, revealing inelastic losses at the universal rate. The thesis reports one of the most accurate measurements of a molecule's vibrational transition frequency to date. The molecular clock lays the groundwork for explorations into terahertz metrology, quantum chemistry, and fundamental interactions at atomic length scales.
