Low Loss Acoustic Cavities: from Frequency Control to Fundamental Physics

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Phonons, quanta of Acoustic vibration, have much in common with photons, elementary excitation of Electro- Magnetic fields. Despite the fact that photonic devices have dominated physics and engineering for at least a century, and the acoustical systems have almost been forgotten. One of the main reasons for that is much lower energy losses exhibited by well-designed photonic systems, e.g. optical cavities. The situation started to change over the last decade when practical implementation of extremely low loss resonant acoustical systems at low temperatures was demonstrated. This was achieved due to exceptional engineering of phonon trapping Quartz Bulk Acoustic Wave (BAW) devices that have much in common with optical Fabry-Perot cavities. Initially used in frequency control devices, BAW resonators demonstrated that at low temperatures their performance is only limited by fundamental phonon-phonon interaction as well as two level systems. With Quality factors well exceeding 10^9 in many modes, BAW cavities often outperform many photonic counterparts and open new possibilities in physics and engineering. Started from a systematic measurement of losses in a solid state, this research lead to a discovery of a physical platform that can answer some fundamental questions about our Universe such as validity of fundamental symmetries postulated in all current theories, existence of Dark Matter, Quantum Gravity, variation of fundamental constants and primordial gravitational waves. Moreover, many research groups started to use such acoustic systems as a building block of Quantum Hybrid systems, a future base for quantum computing, measurement, and control.