Friction sound: A fundamental mechanism of dissipation at the origin of friction force

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Abstract

Friction sound is generated when two solids in contact are rubbed on against each other. Among several types of friction sound, we may separate those whose origin is local or global mechanical instability, such as squeal noise, squeak noise that appears in doors, breaks, tyres, belts... and those whose origin is the mechanical interaction of rough surfaces at the microscopic level. In this study, we examine the fundamental mechanism generating the so-called *roughness noise*, the second class of friction sound.

We show that the generation of vibration is due to mechanical impacts between surface asperities of antagonist surfaces. These light shocks, appearing at the scale of micrometer, constitute a large population of fundamentally unpredictable events. Application of statistical mechanics is therefore the appropriate theoretical tool for its study. We show that the vibration induced by roughness noise is disordered, exactly like the vibration of atoms but confined in the audio frequency band, and then may be considered as heat. An estimation of the modal energy stored in mechanical modes of the solids highlights that the vibrational energy has an acoustical temperature of order of 10ˆ{15} K. Fortunately, this temperature localized in a narrow band of low frequencies of order of kilohertz, is not in thermal equilibrium with physical temperature of order few hundreds kelvins but localized in a wide band of frequencies beyond gigahertz (the natural frequency of the molecule H_2O is 22.3 GHz).

We propose to interpret roughness noise as a transfer of mechanical energy of the sliding solid into vibrational energy of surfaces. This transformation may be viewed as a dissipation mechanism of the kinetic energy. A such, this dissipation is responsible of the emergence of a force to maintain constant the speed of the sliding solid. From experimental results, we have measured the power required to produce a roughness noise. This power is converted in a force standing in the way of the motion, and compared it with the friction force. It results that roughness noise is responsible of a very small part of the dissipation by friction but not so small considering the narrowness of the audio frequency band.

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