Theoretical and experimental study of energetic properties of confined sound fields

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The contemporary history of room acoustics began at the end of the 19th century, thanks to the pioneer works by Wallace Clement Sabine, regarding the interpretation of reverberation processes in large halls. The study, for sure one of the most challenging in acoustics, was carried out inducing the global energetic behaviour of the environment from a local analysis of the sound decay. In practice, Sabine performed several experiments about the decay velocity just by listening to the sound occurring after having shut a steady source (an organ pipe) off, then he devised the first formula describing the energy decay rate (Sabine formula). This was subsequently interpreted according to the whole energy balance linking the energy rate of increase to the difference of rates of energy production and absorption respectively. The essential point which made this available was the assumption that the time rate of change is independent of the position where the decay is perceived and measured during the reverberation process. In short, the local energy density and energy flux density, are supposed to be homogeneously and isotropically distributed over the volume. On the other hand, this statistical assumption, which is referred to in the literature as the ‘‘diffuse field hypothesis’’, has never been carefully interpreted, so that nowadays a deep investigation of the relationship between local and global quantities is still lacking. In the research area just mentioned the purpose of the present thesis is that of giving a contribution to the development of the analysis of confined fields, both from the theoretical and experimental viewpoint. First of all, the task will be approached by introducing a proper formal apparatus for expressing the energy transfer; after that, by the implementation of new intensimetric procedures, it will be shown how the local quantities previously defined are related to the overall structural properties of the acoustic field. The entire work is subdivided in four chapters: below we summarize the main arguments treated in each of them. (1) The most important quantities and physical laws of linear acoustics theory are introduced and discussed. A particular attention is devoted to the reformulation of energy fluxes in terms of the radiating and oscillating intensity. (2) A short review of acoustics phenomena characterizing acoustic confined fields is given, by means of a wave and a statistical treatment. The main original subject which will be discussed is that of the impulse response technique, employed for obtaining the potential and the kinetic energy behaviour during the sound decay (extension of Schroeder’s method). (3) The experimental techniques adopted for measuring the energetic quantities are here illustrated. These include the standard pressure-pressure method for the intensity measurements as well as the cross-correlation procedure for determining pressure and velocity impulse responses and the convolution procedures (FFT, Hadamard transforms) for reconstructing stationary signals. (4) The last part regards the discussion of the results obtained from a set of experiments performed in particular confined fields: an organ pipe, a plexiglass duct and an opera house (‘‘Teatro Comunale’’ in Ferrara).

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