# ULTRASONIC BACKSCATTERING: FUNDAMENTALS AND APPLICATIONS

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## INTRODUCTION

Ultrasonics denotes mechanical vibrations at frequencies of approximately 16 kHz to 1 GHz. Because of its quasi-optical propagation behavior, in medicine and technical applications, ultrasonics is chiefly used to image or detect objects. The two acoustic parameters determining the transparency or the ability of the ultrasonic wave to penetrate matter are absorption which indicates the quantity of ultrasonic energy transformed into heat in the specimen, and scattering. Scattering means that an ultrasonic wave when striking an obstacle radiates part of its energy in all spatial directions.

When the diameter d of the scattering center is very small compared with the ultrasonic wavelength $\lambda$, the so-called Rayleigh scattering (Fig. 1) occurs. Rayleigh scattering increases very strongly with frequency f, i.e. with the 4th power of the frequency. This frequency dependence is observed, for example, when blood is exposed to ultrasonic waves. The blood corpuscles give rise to scattering. An example from optics, where basically the same scattering laws hold, is our atmosphere. Its gas molecules scatter sunlight, particularly the high-frequency components of the visible spectrum, and thus produce the blue color of the sky. When the diameter of the scattering center is of the order of magnitude of the wavelength, stochastic scattering is encountered. Such a marked directional dependence is caused, for example, by a single thread stretched in a water tank. Stochastic scattering increases only with the 2nd power of the frequency. In stochastic scattering, the scattering centers are great compared with the wavelength but distinctly smaller than the diameter of the incident sound beam. Scattering is then produced by the diffuse reflection of the incident sound wave in the scattering centers, for example, in the shrinkage cavities of a metal specimen. This so-called diffuse scattering is independent of frequency.

## BACKSCATTER METHOD

The backscattered signal can readily be detected by experiment by the well-known pulse echo technique. In this method, an ultrasonic transducer radiates a short ultrasonic burst into the specimen to be investigated, for example, a steel plate. As the pulse hits the specimen surface at an angle of 90°, the transducer first receives the echo from the front and a little later also the echo from the back face of the specimen. All additional echoes occurring between these surface echoes are provoked by structural defects such as shrinkage cavities or slag inclusions. In order that very small defects might be revealed, the received signal is often amplified until the background between the echoes distinctly increases to values above zero. The background is produced by the scattered waves which

*Physical Acoustics*, Edited by O. Leroy and M. A. Breazeale
Plenum Press, New York, 1991

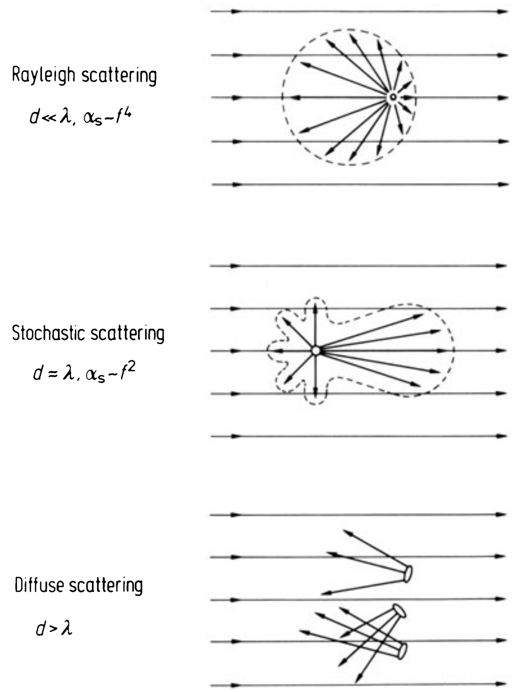


Fig. 1. Ultrasonic scattering.[1]

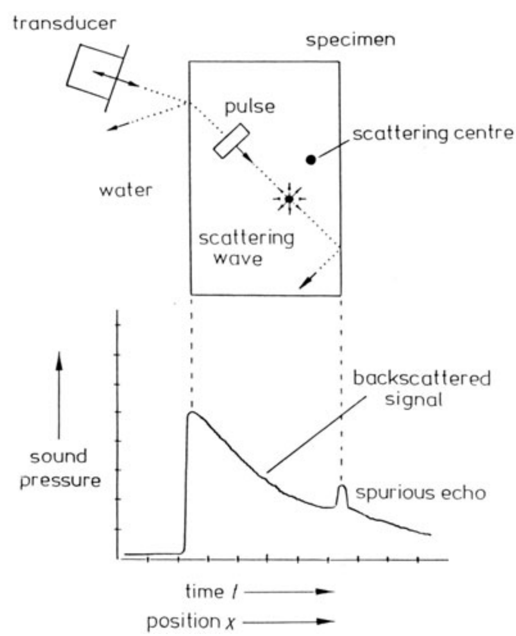


Fig. 2. Backscatter method.