

**AVICENNA, QUESTIONS OF ACOUSTICS IN PHYSICS**

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The soul is pure crystal, a lamp – science,  
Burning oil is the wisdom of man.  
You come alive when wisdom scatters the light,  
You freeze when the brilliance of science is obscured by ignorance.

**ANNOTATION**

The article briefly reveals some of the views of the famous medieval scientist-encyclopedist Abu Ali ibn Sina (Avicenna, 980-1037) about acoustics in Physics. Based on the study of natural sciences from the physical part of the treatise "Sawdust of Nature" ("Kurozai Tabiyet"), specially dedicated to acoustics. It is characteristic that it is in this treatise that Avicenna treats some problems of acoustics from the point of view of the "science of nature" Physics" of that time. In the medieval East, many prominent scientists addressed the problems of acoustics: such as Abu Nasr al-Farabi, Abu Ali ibn al-Haysam and Avicenna himself. It received a special development in the Middle Ages in connection with the development of music theory issues. It was also considered in a philosophical aspect.

The article has an interdisciplinary character, written at the junction of the subject of physics and history, taking into account historical and scientific analysis.

**Keywords:** physics of acoustics, natural sciences, analogy with pyrrhine mechanical motion, history, civilization, primary elements of nature, sound vibrations, echoes, sound, violent movement, Averroes (Ibn Rushd), Abu Nasr al Farabi, Abu Ali ibn al-Haysam, Ibn Sina (Avicenna).

1042 years separate us from the era when Abu Ali Husayn ibn Hasan ibn Ali ibn Sina (Avicenna) lived.

Great scientists with world-renowned representatives of science and culture like bright stars illuminate the path of all mankind. They are the founders of world civilization, and that is why they belong to all peoples and nations.

Avicenna's works on physics or, more precisely, the questions of physics in Avicenna's works, although they attracted the attention of researchers, are in fact still poorly studied. The scientific heritage of Avicenna treats the problems of many sections of physics: mechanics,

acoustics, optics, theory of heat, etc.

Acoustics, along with optics, is one of the oldest branches of physics, widely known in antiquity. In the medieval East, many prominent scientists addressed the problems of acoustics: such as Abu Nasr al-Farabi, Abu Ali ibn al-Haysam and Avicenna himself. It received a special development in the Middle Ages in connection with the development of music theory issues. It was also considered in a philosophical aspect.

Below we will consider three chapters from the physical part of the treatise "Sawdust of Nature" ("Kurozai Tabiyet"), specifically devoted to acoustics. It is characteristic that it is in this treatise that Avicenna treats some problems of acoustics from the point of view of the "science of nature" Physics" of that time.

Let us turn directly to the text of the treatise. According to its structure, the treatise is built in the form of questions and answers.

Question :Why, if you hit some metal vessels, they make a ringing sound, and after you touch them with your hand, the ringing stops, and the lead and lead are not so?

Answer:there are a lot of judgments about sound, its types and causes. It is difficult to explain them in detail, it is extensive and goes beyond the book. Therefore, we will answer only directly to the question posed. They say sound is the impact of an object on an object. The sound comes only from a moving object. If the object is at rest, then there will be no sound.

When the air comes out of the gorge, it hits the air with a durga, and thus the movement of the (initially resting) air begins. This air movement is accelerating all the time and (eventually) there is his hesitation. As soon as movement begins, it generates sound. If the movement stops, the sound disappears.

An analogy of air fluctuations and its state is, for example, throwing a stone into water. If you throw a stone into the water, circles appear in the water, which diverge until the oscillation of the water stops.

Let's get drunk, (with us ) there is a metal vessel or basin. If you hit the vessel, it will start moving and a sequential movement will begin. Sequential movement consists in the fact that when, for example, you pull a spear, it moves entirely, and if its parts are equal on average in thickness, then the sound generated by the spear will last longer.

As soon as it starts moving, the movement (of the air) around it will accompany it all the way to the end. If you put your hand on it, it will not miss the movement, further, and it will stop from the movement (of the hand). An example of this is a barrier along the (flow) of the hand.

If you take a thick ingot of zinc or iron, then there will be no ringing when it hits. Since the ingot makes one movement with one blow, it makes only one sound. Tin is a soft metal, and its particles are loosely adjacent to each other. Therefore, it (on impact) does not ring. Similarly, there will be no ringing from lead because of its great softness.

For example, if you twist a wet string, it does not make a ringing sound. And when (it) dries, the ringing will appear. And the wet drum behaves the same way. When (he) is very much dried, the sound from him will not be long. (It) should be dried normally, and the string as well.

Consequently, the reason for the appearance of sound from some metal and other vessels is Here Avicenna touches on one of the essential issues of acoustics, explaining at the same time both the reason for the volume of sound and the reason for its appearance as a result of the impact of an object on an object and the subsequent vibration of the air generated by it.

Further, the acoustic phenomenon, he actually reduces to mechanical motion, as was done by almost all subsequent generations of scientists up to the authors of modern theories.

His example of throwing a stone into water is interesting, from which it follows that Avicenna perfectly imagined the connection between sound vibrations and mechanical motion - by the propagation of waves from an object thrown into the water. And the theory of mechanical motion, its source and mechanism was in the center of his attention, and this is reflected in some of his encyclopedic writings, for example, in the "Book of Healing" ("Qito bash-Shifo") and the "Book of Knowledge" ("Donish-name"). Above, we have described in detail his concept of the cause and source of mechanical movement, both natural and violent.

Very important are his remarks about the amplification and attenuation of sound, which he associates with

the acceleration and deceleration of mechanical motion that generates sound and promotes its propagation. His remark about the obstacle placed in the way of sound, as well as about the volume of sound produced by different metals and organic substances, is also interesting.

The explanation given by Avicenna is related to the density of matter. Modern mechanics explains these phenomena by means of the phenomenon of elastic and residual deformation of metals and other substances. However, both the elasticity and deformation of the object, as we now know, are related to its density. Therefore, Avicenna, in his explanation of this phenomenon, was, one might say, on the way to understanding its essence.

In the fifth chapter, Avicenna discusses one of the most interesting, although outwardly simple, physical phenomena.

Vapros: why does the one standing at the top hear the voice of the one standing at the bottom better than the one standing at the bottom hears the voice of the one standing at the top?

Answer: Due to the fact that the impact (which generates) the sound (of the voice standing above) moves the air downwards towards the center of the Earth. His movement will be violent, the air (accompanied) by this blow. And since the impact (of the sound coming from the person standing below) is directed upwards, the air in its movement obeys more (almost does not resist) (the impact). This air intrusion is not violent, since its (natural) place is at the top. Therefore, for this reason, the movement of air and its movement from below (up) should be less (intense), and from above (down) more (intense). Because of this, standing at the top is better than the voice of standing at the bottom, than vice versa.

In explaining this phenomenon, Avicenna uses an analogy with rectilinear mechanical movement. He departs from the Aristotelian physics, which goes back to Plato's teaching about the four elements and his own idea of "natural" and "forced" movements.

Every body strives for its "natural place". For heavy bodies, this is the Earth, so they tend to go down. The lungs of the body -for example, air, tend upwards. This is what Avicenna says about "natural" and "violent" movements. Every body strives for its "natural place". For heavy bodies, this is the Earth, so they tend to go down. The lungs of the body -for example, air, tend upwards. This is what Avicenna says about "natural" and "violent" movements. "Movement by compulsion, i.e., "violent movement" consists in the fact that the body moves from one of its own place to another of its own place. The cause of movement is outside the essence of the body. The "natural" movement," he continues, "happens by itself."

When the sound propagates from the bottom up, its "impact" causes the movement and direction of the "natural place" of the air. This is a "natural movement" for sound and therefore it is not extinguished.

A "violent movement" directed in the direction opposite to the "natural" one, as it were, acts against the "natural tendency" of the air upward, and therefore this blow of air is "extinguished". This is the essence of Avicenna's explanation.

Avicenna correctly notes that as a result of the impact of the sound coming from the vocal cords, the air fluctuates, and it is more difficult to spread to the ground.

Than from the Ground up. Based on the theory of four primary elements of nature - the elements (air, earth, fire, water), Avicenna points out that the cause of this phenomenon is the "natural place" of one of them - air.

According to this theory, the "light" elements (air and fire) are located above everything in the universe, and the "heavy" elements (water and earth) are located below everything.

From the point of view of modern acoustics, this is explained as follows.

Sound vibrations in the air are more easily spread out in the direction where there are no large obstacles (the size of which is much larger than the wavelength of sound vibrations) This is due to the fact that the reflected wave, reflecting from the presence (for example, from the Earth), interferes with the incident wave, as a result of which it can extinguish sound vibrations.

The next question will be considered from the tenth chapter.

Question: Why is the cry not heard in the desert, but heard in the mountains?

Answer: Because the sound is like the movement of a wave.

This is a phenomenon that occurs from hitting the air, as a result of which the air becomes mobile. When a sound is made in the desert, it hits (the surrounding sound source) air. The air moves and (then) goes a long way. The approximation is transmitted over a long distance, but (at the same time) gradually slows down. The air (again) becomes motionless, and the sound, beaming from (the movement of the air), there (gradually) fades and disappears. For this reason (in the desert) the sound is not heard far away.

When the sound arises in the mountains and gorges, it hits the air between the mountains. The air (under the influence of sound) becomes mobile, (and begins to move). And since he does not find a way, because (he) is hindered by the mountains, the air in its movement (in the form of a wave) returns back (to the mountains), to where it comes from. The sound, obeying this movement, also returns back, and it seems to people that a stupid person is shouting.

An example of this: on the water, if you throw a stone into a pond, waves appear. The movement of water will reach the edge of the reservoir, and not finding a way further, it returns in the form of waves back in the direction from which (it) came. Similarly, a sunbeam is reflected on a smooth body, it is clear that a cry in (gros) is a reflection of a sound that does not find a way for its (further) movement.

Here Avicenna explains the reason for the echo in the mountains. And in general, this explanation corresponds to the modern view, since it reduces it to the movement (oscillation) of air and the formation of waves. Avicenna expounds this point of view more clearly in the Book of Knowledge: "Sound," he says, "appears as a result of air vibrations and motion when two bodies collide with each other, and the air repels from them and causes vibrations. These waves travel very fast. Or a strong oscillation occurs when air passes with a pressure through some

body, and this oscillation spreads rapidly. It is the reflection of sound waves in the air from the mountains that causes the echo. The sound does not seem to find its way through such an obstacle as mountains and returns back, reflecting from them.

It is very important that here Avicenna resorts to a mechanical analogy in the form of an example of throwing a stone into water. This classic example was later, in the 19th century, following Avicenna, cited by the largest philosopher of the Eastern Middle Ages, an active supporter of the teachings of Aristotle - Averroes (Ibn Rushd, 1126-1198). Using this example, Averroes explained the mechanism of the motion transfer.

For example, Averroes, referring to the essence of the process of transmitting motion, compares it with the propagation of waves in circles through the water from the place where the stone is thrown, proceeding from the analogy between two media - air and water.

In the end, regarding the influence of Ibn Sina's works on the work of scientists of the subsequent generation of East and West, we can say that a comprehensive and in-depth study of the "Avicenna school" will give much unexplored aspects of his work and will constitute a separate difficult scientific work for Avicenna scholars.

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