STATIC SPEAKER

Seyed Mohammad Hoseini Yamin , Shahid Beheshti University
Co- Authors: Reza Pourkodabakhshi, Sina Ghafouri, Armin Tabesh

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Minds Institute , AYIMI

http://www.ayimi.org ,info@ayimi.org

A B S T R A C T

Producing sound in different conditions is conceptually interesting. In the other hand, use of sounds for our objectives are attractive, too. For example, some people think about thermoacoustic engines to make heat with sound and reversely produce heat using of sound. The last has more application for our routine life. Here with the aid of fundamental concept of Physics we were able to produce sound in new way. We use the fourth discovered phase of matter, plasma .

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1. Introduction

Producing sound in different conditions is conceptually interesting. In the other hand, use of sounds for our objectives are attractive, too. For example, some people think about thermo acoustic engines to make heat with sound and reversely produce heat using of sound. The last has more application for our routine life. Here with the aid of fundamental concept of Physics we were able to produce sound in new way. We use the fourth discovered phase of matter, plasma, as you know, is the quasi-neutral gas shape material that consist of ions with same number of e[illegible]ust satisfy two conditions. One is that in the media there must be a Restoring force that affect the wave fronts. Here compressibility of gas provides it for us and second is the media must have inertia. Inertia refer to property of matter does not enable a body to do anything except oppose such active agents as forces and torques. In fact, the inertia of the ions allow the sound propagate through matter. If there not be inertia, the agents that transport the mechanical wave (sound) will move with the wave and we can`t detect anything. Maybe just some noises. A plasma arc speaker is an improvement on the traditional diaphragm loudspeaker because the driver, electrical arc has very little mass and low inertia, reducing distortion. It is capable of producing very high frequencies due to its ability to move very small quantities of the gas.

The ions in plasma have sound-like Response, however electrons participate in these oscillations. This sound-like behavior named, Ion Acoustic Wave.

2. Related reports, technologies or devices

1. One of the interesting works on this area is Graphene Speaker. For the aid of producing sound, they flow current through Graphene. To produce sound, the grapheme layer is rapidly heated and cooled, which in turn causes the surrounding air to expand and contract, creating sound waves. By strategically controlling the alternating electrical current flowing through the Graphene, the scientists also found they can mix frequencies together, and even amplify or equalize specific sounds. Which means the amp, EQ, and towering speakers that make up most home stereos might one day be replaced by a single, solid-state device.

2. A cone less, no-moving-parts dynamic speaker has its internal components firmly locked within a plastic housing structure to prevent their movement relative to the housing. During operation of the speaker, mechanical sound energy that it creates is transmitted through the walls and ceiling of the room to provide an expanded sound generation pattern. The internal components of the speaker include a voice coil internally anchored to a wall of the housing, an annular magnet member sandwiched between and fixedly secured to first and second annular metal washer members, and a metal alignment shaft having one end closely received in the core portion of the voice coil, and an opposite, radially enlarged end press-fitted into one of the washers and forming with the side surface of the central magnet member opening a reverberation chamber which is closely adjacent the voice coil but does not physically receive the coil. In an alternate embodiment of the speaker the housing is foreshortened in a manner exposing the magnet member and the washer member into which the radially enlarged end portion of the alignment shaft is press-fitted.

3. Another amazing device is Controlled Resonance Technology. It does not use conventional drivers to reproduce sound.CRT on the other hand uses a soundboard much like a musical instrument to reproduce sound. The soundboard uses resonances to generate sound-wave. By generating resonance originating from multiple locations on the board. A board frequency range can be generated within very small fluctuations in amplitude.

4. As an idea in our objective is producing sound by strong electromagnet that change its polarity and then push and pull the charged gas that surrounded the electromagnet. Finally alternating of polarity of electromagnet will produce pressure waves or roughly speaking, sound.

3. Aims and methodology

As was explained in abstract, we use plasma for producing sound. Plasma has two different type named Warm plasma and Cold plasma. Here we use cold arc plasma. The temperature of electron in such plasma can reach about 3ev (1ev ~ 11600 k) then the "cold" refers to ions and ambient neutral species.

Plasma can be created with arc discharge in The Gas. Arc regime is third discharge regime after Glow discharge and Corona discharge. When the high-voltage power supply applied between two electrodes, first corona regime that is ionizing of atoms near high voltage probes so combination of electrons and ions will appear and with increasing the discharge current, those two region get together that basically create region of the gas that`s basically full of electrons and ions that named "plasma". It essentially become a conductor and goes too huge current between two probes. This is called an arc discharge.

Since the plasma was made of Electrical Arc, it is important to mention plasma arcs have a major advantage. They have no resonance or transient problem. Most audiophiles know that the lighter the material used in a speaker, the faster the response can be, and the better transient they produce. Plasma speaker, works by moving air via changing the temperature in its chamber. A plasma speaker uses an electrical arc to ionize and compress the air around it to play music, all with no moving parts! Actually plasma arc loud speaker has a better frequency response far exceeding the material of speaker cones.

It`s so important to say that the speed of sound in plasma is bigger than its speed in air. Another advantage about plasma is the speed of electron with considering motionless ions is much bigger than propagation speed of sound and subsequently, we don`t face with resonance of sound wave and it causes to be any noises on played music and we detect frequencies of played music sharply in the contrary of ordinary speakers. Meanwhile for many purposes, the conductivity of a plasma may be treated as infinite.

Starting with simplified one-fluid equations with considering a field-free uniform plasma ($E0 = B0 = P0 = V0 = 0$) of hot electrons and cold ions and then considering small perturbation in density and velocity about steady state with linearization and simplifying and providing third equation that is poisson`s equation we reach to dispersion relation for plasma and with solving $\epsilon(\omega) = 0$, propagation modes will be found.

$$\partial_t(n_{i,e}) + \partial_x(n_{i,e} V_{i,e}) = 0$$

$$\partial_t(V_{i,e}) + V_{i,e}\,(\partial_x(V_{i,e})) = -\, q_{i,e}/m_{i,e}\,(\partial_x(\phi))$$

$$\partial_{xx}(\phi) = -4\pi e(n_i - n_e)$$

With the approximation $n_e = n_i$ and $V.\nabla V = 0$, these reduce to the one-fluid equation.
Small harmonic perturbations are:

$$n_\alpha = n_{\alpha 0} + \hat{n}_{\alpha 1}(x)e^{-i\omega t}$$

$$V_\alpha = \hat{V}_{\alpha 1}(x)e^{-i\omega t}$$

$$E = \hat{E}_1(x)e^{-i\omega t}$$

$$B = \hat{B}_1(x)e^{-i\omega t}$$

So the continuity equation for the perturbed density and velocity is :

$$i\omega n_{i1} - in_0\, K \cdot V_{i1} = 0$$

$$i\omega n_{e1} - in_0\, K \cdot V_{e1} = 0$$

The momentum transport equation for the perturbed quantities, including electron pressure, is :

$$-i\omega V_{i1} = e/m_i\, E_1$$

$$-i\omega V_{e1} = e/m_e\, E_1 + (iK\gamma p_0/n_0 m_e)(n_{e1}/n_0)$$

Where γ is the intrinsic feature of the gas that here for air is equal to 1.
Poisson`s equation provide a third relation between n_1, V_1 and E_1.

$$iK.E_1 = -4\pi e(n_i - n_e)$$

Eliminating V between Eq.5 and Eq.6 and then substituting n_{i1} and n_{e1} from state equation for ideal gases ($p = nk_BT$) into Eq.(7) gives this result :

$$(1 - (\omega_{pi}/\omega)^2 - (\omega_{pe}/\omega)^2(1/(1-(K^2/\omega^2)(\gamma k_B T_e/m_e)))) K \cdot E_1 = 0$$

A reasonable choice of γ might be $\gamma = 1$ from isothermal processes. From equivalent dielectric constant for a plasma of warm electrons and cold ions is :

$$\epsilon = (1 - (\omega_{pi}/\omega)^2 - (\omega_{pe}/\omega)^2(1/(1-(K^2/\omega^2)(\gamma k_B T_e/m_e))))$$

Instead of using Poisson`s equation, Eqs. (5) and (6) can be combined with Maxwell`s equation:

$$\nabla \times \mathbf{B} = (4\pi \mathbf{J}/c) + (1/c)\, \partial_t(E)$$

To give

$$\nabla \times \mathbf{B}_1 = -i\omega\epsilon\, E_1$$

Now K dotted into Eq.(9) yields to Eq.(7), singling out the electrostatic waves ($B_1 = 0$).
In addition, Eq.(9) includes electromagnetic waves ($K.E_1 = 0$, a wave with its electric field perpendicular to its direction of propagation.)
So dispersion relations become:

$$\omega^2 = \omega_p^2 + (k_B T_e/m_e)K^2$$

$$\omega = \omega_p(1 + k_B T_e/m_e\omega_p^2 K^2)$$

$$\omega = K((k_B T_e/m_i)^{1/2} / (1 + k^2 \lambda_{De}^2)^{1/2}$$

where:

$$\lambda_{De} = k_B T_e/4\pi ne^2$$

The dispersion relation is still valid only for long-wavelength disturbances, i.e,for $K^2(k_B T_e/m_e) << \omega_p 2$ (equivalent to $K^2 \lambda_{De}^2 << 1$), so the sound wave propagate with the speed:

$$\partial_K(\omega) \approx C_s = (k_B T_e/m_i)^{1/2} << (k_B T_e/m_e)^{1/2}$$

And is less than the electron thermal speed. It`s necessary to mention that our assumption ($\gamma = 1$,propagation of sound in plasma is isothermal processes) is valid because the electrons moves faster than the wave fronts or, roughly speaking, the ions and so they dose not sense any change in their surrounding temperature. It means that propagation of sound in plasma pass an isothermal process.

4. Experiments and Results

Setup was constructed from a high-voltage power supply, a pulse generator and two electrodes. Pulse generator provide our arbitrary music with coupled frequencies and put it on plasma via high-voltage power supply (Fig. 1).

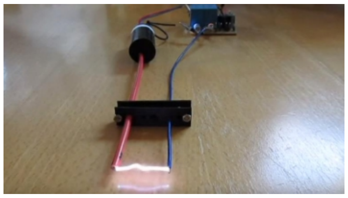

Fig. 1: Experimental Setup

In the below there is comparison of "Amplitude – Impulse Response (Frequency Response)" plots between two different speakers. As you see the Plasma speaker (left plot) enjoy a clear and noiseless impulse response. While in the RealTek HD speaker (right plot) the frequencies did not detect sharply and there is a lot of noises in output sound (Fig.2) .

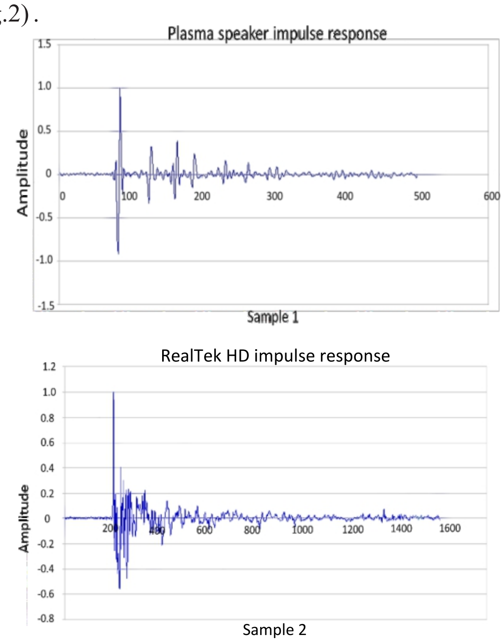

Fig. 2: comparison of "Amplitude – Impulse Response (Frequency Response)" plots between two different speakers

A plasma arc speaker was made and its operation was studied. By use of the plasma speaker we have attempted to study the phenomenon of electric discharge through the ionization of air molecules.

The plasma speaker has unparalleled performance and fidelity in the higher ranges. The unique nature of its "massless" driver gives it very low coloration. As a specialized tweeter it may do very well in combination with a subwoofer. Low frequencies are naturally less directional than high frequencies, so a conventional subwoofer in combination with a plasma tweeter could theoretically show an even frequency response.

*This analysis belong to Sylvan Zheng.

An interactive report on the acoustical qualities of a plasma loudspeaker

Plasma Speaker Experiment | Princeton Plasma Physics Lab