E-NEWSLETTER

June 2017 issue

THE SOCIETY OF ACOUSTICS SINGAPORE

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Year of Registration: 1989

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CONTENTS

I CONFERENCE NEWS

The 24th International Congress on Sound and Vibration(ICSV24) will be held in London, UK from 23 to 27 July 2017.

Woon Siong Gan will be organising three structured sessions on:

1. **Nonlinear acoustics and vibration**
2. **Acoustical metamaterials:theory and applications**
3. **Sound propagation in curvilinear spacetime**

Please visit www.icsv24.org for more informations.

2. CONFERENCE NEWS

The Society of Acoustics(Singapore) and the Indonesian Association of Vibration and Acoustics will be jointly organising the Regional Conference on Acoustics and Vibration from 26 to 29 Nov 2017 in Bali. Please visit the conference website: www.aavi.its.ac.id for more informations. The abstracts deadline has been extended to 4 August 2017. The registration fee is rather low only USD450.

II. ANNONCEMENTS

The Society of Acoustics will be sending out invoices to members with outstanding membership subscriptions. Members are encouraged to make payment in support of the Society.

The E-Newsletters will be made available to industrial contacts in an effort to promote the activities of the Society.

The Society is also exploring the possibility of organising talks and other professional events in collaboration with acoustic societies of other countries.

The Society aims to increase membership by inviting all persons, including those from the institution of higher learning and other related societies such as the Institute of Architects, Singapore and the members of the mechanical engineering division of the Institution of Engineers, Singapore who are qualified in the various field of Acoustics to join our Society.

We are especially keen to invite students to join our society and we are establishing the Youth Chapter soon.

III. MEMBERSHIP SUBSCRIPTION

Fellow	**S$70**
Member	**S$50**
Associate	**S$30**
Student	**S$15**
Corporate	**S$200**

FEE BASED ON ANNUAL RATE

FOR MORE INFORMATION PLEASE CONTACT: Dr.Gan at email: wsgan5@gmail.com

Membership application forms can be downloaded from the society website: www.acousticssingapore.com. Please complete and email to wsgan5@gmail.com

IV.ARTICLES

Transport Theory is the Key Foundation of Theoretical Metamaterials Design -Metamaterial is Phase Transition

Woon Siong Gan

1.PhD Work revisited --------Introduction of Transport Theory into Condensed Matter Physics

In 1966 W. S. Gan coined the term transport theory during his PhD work in the physics department of Imperial College London. His PhD thesis(1969,Imperial College London) Transport Theory in Magnetoacoustics [1]is the first to introduce transport theory into condensed matter physics. Since then transport theory has undergone tremendous development in linear transport theory, electronic transport theory, nonlinear transport theory, quantum transport theory etc.Today transport theory is the key foundation of the theoretical materials design.[2]. It is the most important theory in condensed matter physics. The status of transport theory in condensed matter physics is equivalent to that of Yang Mills Theory[3] in particle physics.Also in 1967 Philip Warren Anderson and Volke Heine coined the term condensed matter physics when they changed the name of the solid state theory group to condensed matter physics group at Cavendish Lab, Cambridge. , to combine liquid state physics with solid state physics and to reflect the important role of phase transition. Today condensed matter physics group has the largest membership in the American Physical Society. Thus his PhD thesis also played a role in the founding of the field of condensed matter physics.

2.Discovery of Metamaterial as Phase Transition –Metamaterial is a Branch of Condensed Matter Physics

In this paper,my PhD thesis will be revisited. It will be illustrated that metamaterial in fact is a phase transition and metamaterial is a branch of condensed matter physics. , The double negativity of permeability and permeability of electromagnetic metamaterial and double negativity of the effective bulk modulus and the effective mass density of the acoustic metamaterial is phase transition from the positive phase material to the negative phase material. Permeability, permittivity, bulk modulus and mass density are transport properties. Based on the backbone of the transport properties, one is able to discover new forms of metamaterials beyond the electromagnetic metamaterial and the acoustic metamaterial. Metamaterial is a branch of condensed matter physics Metamaterial is a transport phenomenon . Hence transport theory which describes transport properties and transport phenomena is the key foundation of the

theoretical design of metamaterials. Metamaterial is a new material and transport theory is the key foundation of the theoretical design of new materials. Besides this, one does not have to use analogy to extend electromagnetic mematamaterial to acoustic metamamterial. One can base on transport properties, the root of the problem.

3.Singularity Behaviour of Transport Properties at the Critical Point of Phase Transition

The description of metamaterial as a phase transition can be further confirmed by the singularity behaviour of the transport properties of permeability[4] , permittivity[5] and effective bulk modulus[6] during the critical point of phase transition, during the resonance frequency. (Please refer to the plots in Figs. 1,2,3,4).. There is a common behaviour of the transport properties: permeability, permittivity, effective bulk modulus at the critical point of phase transition that at this critical point of resonance frequency they will have a sudden increase in value followed by a sudden drop to a huge negative value and then followed by a gradual rise in value in the negative region. The metamaterial is used in the phase transition of high temperature superconductivty further confirmed that metamaterial is a phase transition.

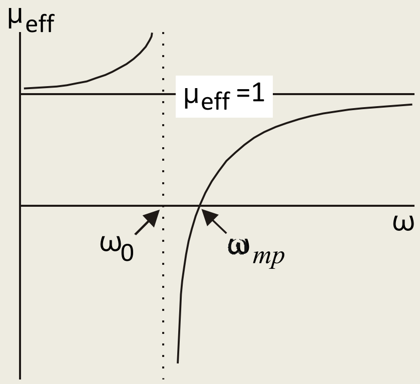


Fig1.Singularity behaviour of permeability in magnetism at the critical point of phase transition[4]

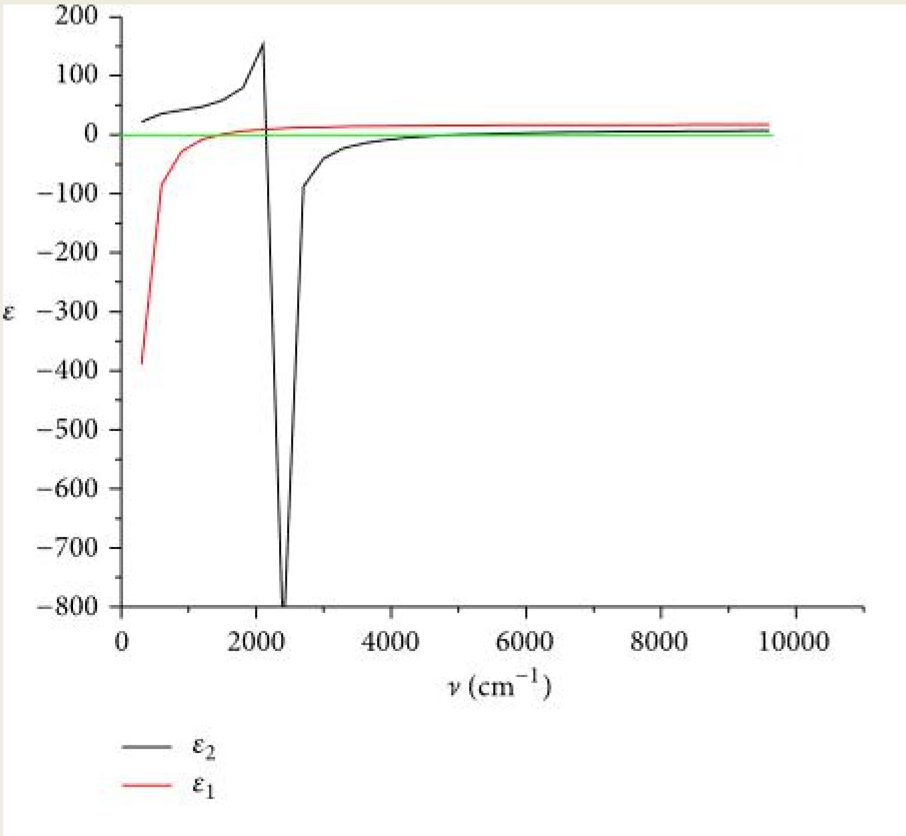
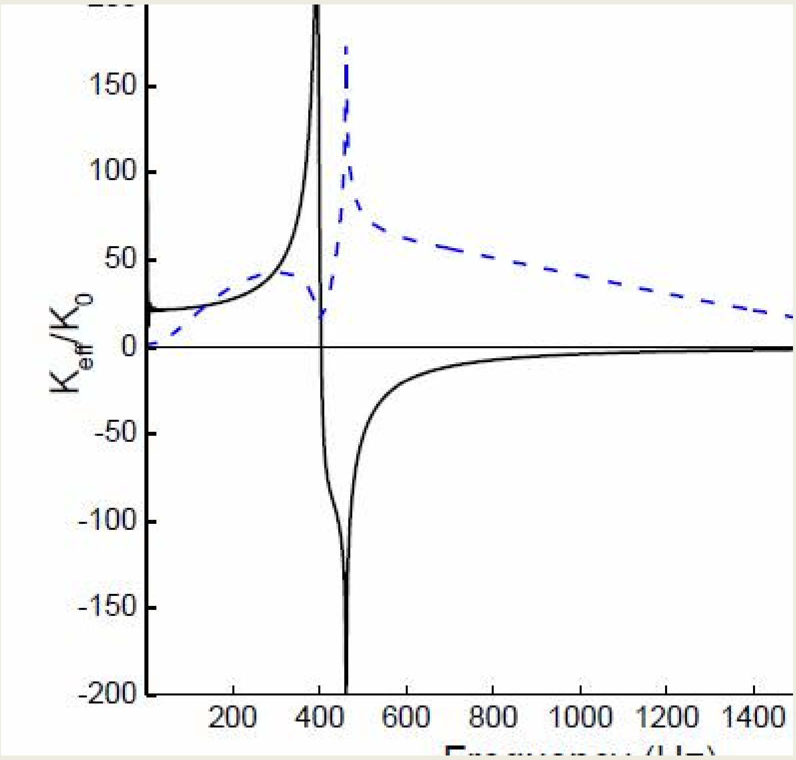


Fig.2.Singularity behaviour of permittivity in high temperature superconductivity at the critical point of phase

transition[5].



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Frequency(Hz) Fig.3. Singularity behaviour of the bulk modulus at the critical point of phase transition or resonance frequency. [6]

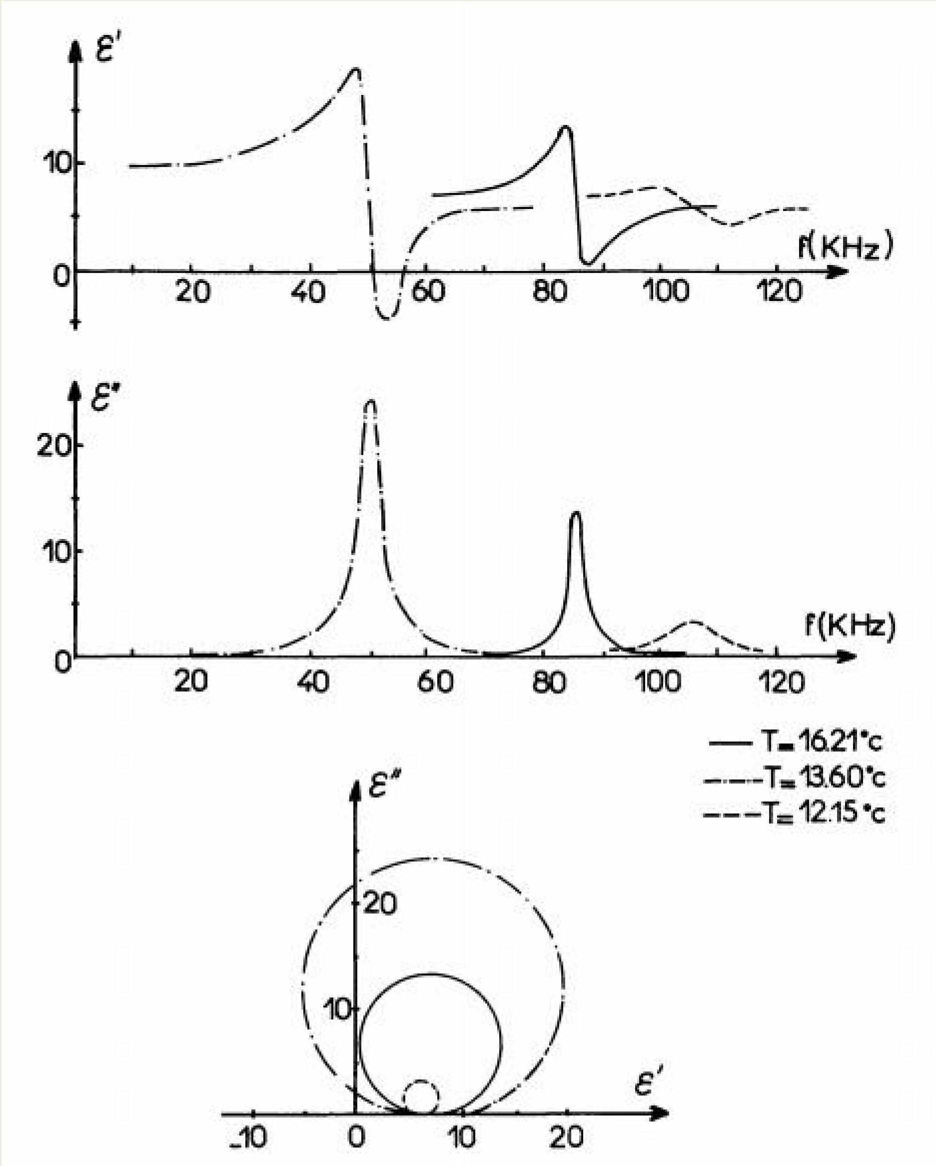

Fig 4. Typical piezoelectric resonance curves and corresponding Cole-Cole diagram for a low frequency acoustic resonance mode observed in the sample $T_{\propto}$ above and below the transition temperature T_c = 13.43^0C.[7].

4.Discovery of other Forms of Metamaterials beyond Electromagnetic and Acoustic Metamaterials

In this paper, based on transport properties, two new forms of metamaterials are introduced. One is the artificial piezoelectricity and another is artificial ferromagnetism based on the transport properties of dielectric constant and dipole moment respectively. The dielectric constant of the piezoelectricity is found to have

the singularity mentioned in the previous paragraph[7]. An immediate fabrication of this form of metamaterial is to use the split ring resonator(SRR) as the unit cell of the piezoelectric metamaterial. The material of the unit cell will be made of piezoelectric material. This allows one to manipulate and control the piezoelectricity. Piezoelectricity provides the physical basis for almost all practical applications of acoustic fields. This is because they provide an effective means for electrically generating and detecting acoustic vibations.

I am in the process of investigating the singularity behaviour of the dipole moment , the transport property of ferromagnetism versus frequencies during phase transition, the critical point or the resonance frequency.

5. Use of Transport Properties to explore New Forms of Metamaterials

The double negativity of electromagnetic metamaterial and acoustic metamaterial and the singularity of the dielectric response function of high temperature superconductivity are first examples of the use of transport properties to discover new forms of metamaterials.

5..1 Artificial Elasticity

The singularity behaviour of the effective bulk modulus at the resonance frequency or critical point of phase transition can be exploited to fabricate acoustic metamaterial[6] Here there is a sudden increase of the effective bulk modulus to a very high value at the resonance frequency followed by a sudden drop to very high negative value and a gradual increase in value in the negative region. This singularity behaviour can be exploited to fabricate acoustic metamaterial using the geometric structure of split ring resonator(SRR) with the unit cell made of elastic material. This enables the control and manipulation of the elasticity of the material. This is artificial elasticity.

5..2 Artificial Magnetism

Pendry et al[4]'s paper on magnetism from conductors and enhanced nonlinear phenomena is an example of artificial magnetism. Here the permeability which is a transport property shows a singularity behaviour at the critical point of phase transition with a sudden rise at the resonance frequency to positive infinite value followed by a sudden drop to negative infinite value and then a gradual rise in the negative region. The negative values of permeability is used to fabricate the negative electromagnetic metamaterial using the SRR geometric structure as the

unit cell of the metamaterial and the material of the unit cell is made of magnetic material. This enables the achievement of an electromagnetic metamaterial experimentally and the manipulation and control of magnetism. This is artificial magnetism.

5..3 Artificial High Temperature Superconductivity

Smolyaninov et al[5] proposed that high temperature superconductivity can be achieved using metamaterial. This is because dielectric response function governing electron-electron

interaction can be used to increase the critical temperature of high temperature superconductivity according to Kirzhnits et al [8]. It is found that the dielectric response function which is a

transport property has singularity behaviour (hyperbolic shape) at the resonance frequency or the crtitical point of phase transition. The dielectric response function versus frequencies plot

shows a sudden increase to high

positive value and then a sudden drop to large negative value followed by a gradual increase in value in the negative region. This behaviour can be exploited in the fabrication of high temperature

superconductor by using a geometric structure of SRR for the unit cell made of high temperature superconductor . This enables one to manipulate and control high temperature

superconductivity.Hence the name high temperature superconductivity metamaterial.

5..4 Artificial Piezoelectricity

Piezoelectricity is an important phenomenon in acoustics. It provides the physical basis for almost all practical applications of acoustic fields. This is because they provide an effective

means for electrically generating and detecting acoustic vibrations. It is found by Legrand et al[7] that the permittivity also has a singularity behaviour at the resonance frequency or point

of phase tranisition with a sudden increase to a very high value followed by a sudden drop to negative value then a gradual increase in value in the negative region. This singularity behaviour

can be used to fabricate artificial piezoelectricity by using a SRR as geometric structure of the unit cell made of piezoelectric material. This will enable the manipulation and control

piezoelectricity. This is artificial piezoelectgricity.

5.5 Artificial Ferromagnetism

In ferromagnetism, according to Joseph Mayer[9], there is some sort of mathematical singularity at the condensation point. The transport property of ferromagnetism is magnetization

or dipole moment. It is of interest to investigate the singularity behaviour of the dipole moment at the critical point of phase transition or condensation point. There will be a temperature

dependence of the dipole moment besides the frequencies dependence. One will have to plot the dipole moment versus the frequencies at a series of temperatures. There will be no singularity

behaviour of the dipole moment versus frequencies plot at other temperatures. However, at the critical temperature of second order phase transition, there will be a hyperbolic shape behaviour

of the dipole moment versus dipole moment versus frequencies plot at other temperatures. However, at the critical temperature of second order phase transition, there will be a hyperbolic shape

behaviour of the dipole moment versus frequencies plot similar to that of the cases of the artificial elasticity, artificial magnetism, and artificial piezoelectricity.

6. Metamaterial as Phase Transition as Breakthrough to a New World of Artificial Materials

Double negativity electromagnetic metamaterial and double negativity acoustic metamaterial are manifestations of artificial magnetism and artificial elasticity. This will be a starting point

for the exploration of various new artificial materials based on metamaterial and phase transition. Immediate examples are artificial piezoelectricity and artificial ferromagnetism. This will

open to a new world of new materials based on other transport properties besides permeability, permittivity, effective bulk modulus and effective mass density.

7. Conclusions

Transport theory has come a long way in tremendous development in condensed matter physics since the term was coined by me in 1966.. It has now become the key foundation of theoretical

materials design.Hence it has become the most important theory in condensed matter physics.

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MINIATURE LOUDSPEAKER WITH PASSIVE RADIATOR

Compiled by Sonny C Y Lim, 15 May 2016

Introduction

It has been once said that size is no compromise for speaker's low frequency (bass) response. In the 1980s manufacturers experimented with "passive radiators" to increase the low frequency response and avoiding the cost of large speaker drivers and cabinets. This is to psychologically equalise the frequency curve characteristic of the sound reproduction for the human ears (which is deficient in the low frequency range) without involving large expensive cabinets and speaker drivers. However, the project did not capture the interest for the reason of the audio harmonics and tonal "colour" of the sound produced by such speaker electroacoustic devices lacking the ambience. Electro-acoustics reproduction of musical instruments and human voices cannot be easily emulated except with air vibration involving the loudspeaker cone and cabinet resonance amplifying the reverberation in the room. Any thing less than that require audio digital processor recreating artificial ambiophonic effects.

Only recently miniature speakers with improved sound reproduction quality are in demand for computer and smart phone users. This time with the availability of the Neodymium magnet to provide the flux density for the loudspeaker drivers, which is about ten times the flux density strength compared with conventional ferrite (iron dust) magnet, enables the loudspeaker voice coil (driver) to produce the mechanical inertia required for the cone excursion in generating the transient in the audio reproduction. The high magnetic energy controls the low frequency response without requiring high electrical energy, which is the main cause for distortion owing to the wide cone excursion. Coupling this to Passive Radiators increases the acoustic diaphragm surface resonance and generating greater air mass modulation and transmission.

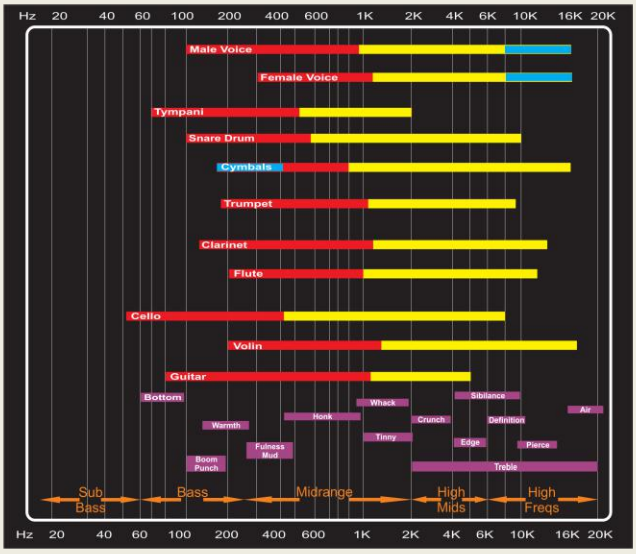

Fig. 1 Musical Instrument and Frequency Range Coverage

Musical instruments cover the whole range of the frequency spectrum from 20 to 20,000 Hertz as shown in Figure 1, the reproduction equipment with the speaker system must be able to handle the frequency range with equal loudness and definition at minimal distortion from wide cone excursion.

How Passive Radiators Work

The passive radiator is a simple acoustic diaphragm, coupled with the air mass in a chamber enclosing the active speaker driver providing the low frequency (Bass) resonance. When coupled optimally and acoustically aligned, the passive radiator can react with the small active speaker drivers to produce the low frequency performance comparable too larger speaker and cabinet.

As the air mass resonates with the active speaker cone, it generates the low frequency working in tandem with the passive radiators for increased bass reproduction, similar to drum diaphragm skin. Passive radiator technology has revolutionised the electro-acoustic principle, allowing it to act as resonators to the trapped air producing low frequencies emphasis without using the complex tuned port with large speaker and cabinet design.

The passive radiator increases the surface area of the speaker diaphragm improving the sound pressure level of the low frequency. Low (bass) frequency is not restricted to the very low frequency, but frequency in the range from 70 and 400-Hertz range. These frequencies, psychologically causes the human ear or should I say brain to perceive as bass frequency resonance, although in real sense the frequency does not go down to 40 Hertz. For example, the kick (bass) drum resonates at 70 Hertz but perceived by the ears as bass beat, especially in discotheque.

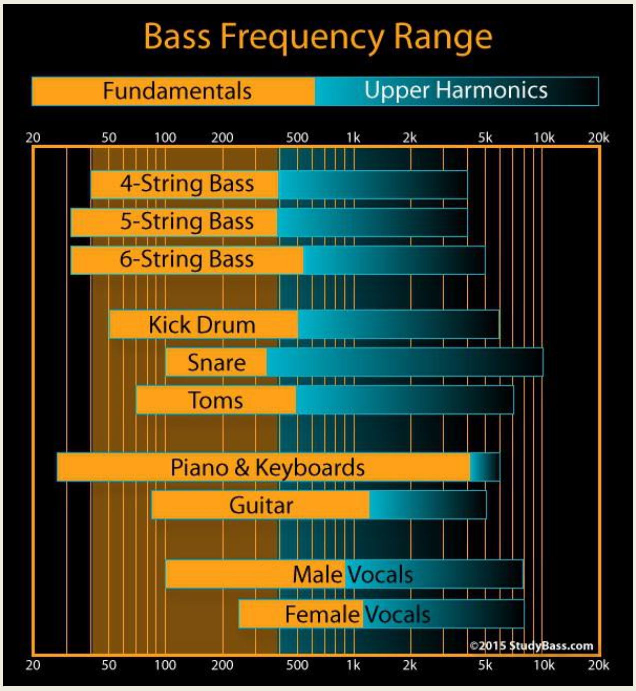

Fig. 2 Musical Instruments and Voices Covering
the Bass Frequency

Figure 2 displays the chart showing various fundamental frequencies of the musical instruments and voices around 400 Hertz, the frequency range generates resonance providing the illusion of enrichmentin on sound perceived.

The human ears' auditory perception is deficient in the low frequency on sound pressure level below 90 decibels by as much as minus 70 decibels at 80 Hertz. This puts the small speaker units at a very disadvantages performance, as they cannot achieve the sound pressure level in excess of 80 decibels. Therefore, the only solution is to develop small speaker systems that can achieve the SPL for the human auditory curves by coupling it with passive radiator.

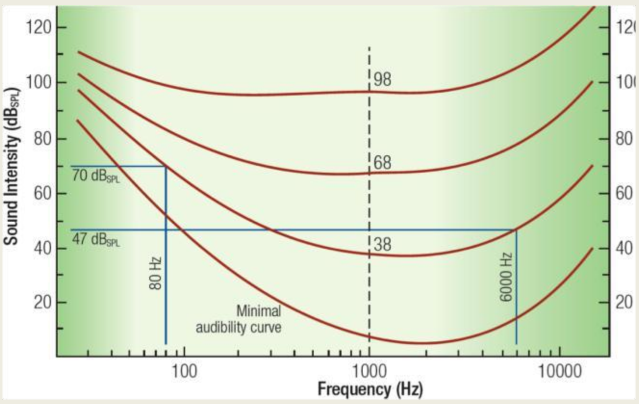

Fig. 3 Frequency Curves Sensitivity of the Human
Ears

The chart in Figure 3 illustrates the compensation curves in SPL required for the human ears to perceive sound with full spectrum frequency range.

For that reason, small or miniature speaker system is unable to satisfy the human listener psychologically and the frequency response curve in Figure 4 illustrates the compensation curve in exactly the opposite to the curves displayed in Figure 3.

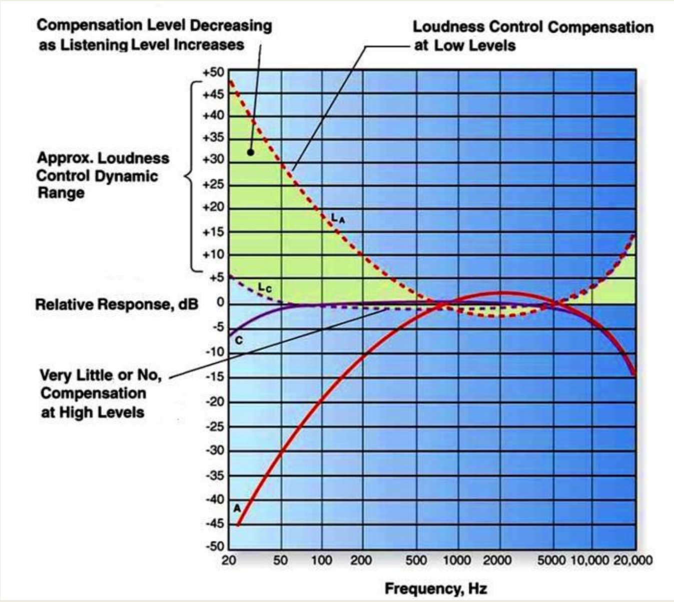

Fig. 4 Loudness (Contour) Equalisation for Human Auditory System.

Sony Concept

In order to allow miniature speaker system to provide the psychological auditory satisfaction for human listening perception, the passive radiator theory is applied, like the Sony SRS X33 Miniature Speaker in Figure 5.

Fig. 5 View of the Sony SRS X33 Miniature Speaker with the Grille on.

Without the grille, the front baffle in Figure 6 shows the two driving loudspeakers and passive radiator.

Fig. 6 Front View with the Grille removed, showing the front two speakers in addition, the passive radiator.

The Sony design further enhances the low frequency with a second passive radiator mounted at the rear, shown in Figure 7, to generate additional sound resonance of the air vibration within the enclosure at the rear and working in tandem with the front passive radiator. They enhance the natural reverberation of the low frequency emulating the electro-acoustic psychological performance of larger speaker system.

Fig. 7 Rear View with the Grille removed, showing the rear passive radiator

Harman Kardon Concept

The Harman Kardon, Esquire 2 Wireless Speaker has approached the concept slightly different using the multiple speaker drivers' configuration to increase the sound pressure level and a single passive radiator to achieve the the low frequency resonance.

Fig. 8 Front View of the Speaker with the Grille.

Fig. 9 Front View with the Grille removed, showing the four active speaker drivers and one passive radiator

The acoustic coupling effect will achieve 3 decibels gain per driver that is double the power output gain by electro-acoustic SPL calculation. Taking the hypothetical speaker efficiency of 60 decibels for 4 X 35mm speaker driver of 1m@1W.

1) One driver - 60 + 10 log8W = 69 decibels
2) Two drivers - 60 + 3 + 10 log8W = 72 decibels

Taking each stereo channel separately there is a 10 decibels gain with two drivers; by adding a passive radiator you further increase the SPL total gain up to 75 decibels. This also increases the low frequency response, for this case the specification states 70 hertz low frequency response, which is normally only achieved with 6 inch driver in a ported cabinet of about 10 times the volume size. Although the bass is not as prominent as the Sony, but the damping is better controlled, without intermodulation distortion.

Active Sound Processor

The introduction of the Digital Sound Processor, does improve the sound reproduction of compact speaker system with passive radiator to emulate coupled with small speaker by providing the psychological sound effect on instruments and voice. However the limitation is still the cabinet resonance and air-mass effect of the sound waves.

Acknowledgements

Part of the article is reproduced from Center Point Audio; the audio division of C. Crane. An American audio design company located in Fortuna, North Coast of California.

Pictures, illustrations and diagrams courtesy of Sony Corporation, Harman International Industries Incorporated and Wikipedia Encyclopedia.

There are more details and aspects to passive radiator technology that this article does not cover.

It is intended is to provide you with simple, simplified explanations of what a passive radiator does and what are some of its benefits are. They encourage you to research this topic further if you are seeking more technical information to better understand a passive radiator's function.

REPORT ON CONFERENCES

Western Pacific Acoustics Conference(WESPAC)- Dec 6 to 10 2015, Grand Copthorne Waterfront Hotel, Singapore

Singapore has the second highest number of 35 participants after the first place Japan with 95 registrations and the third was China with 32 participants.

The breakdown in field categories was as follows

1. **Architectural acoustics 132**
2. **Noise 119**
3. **Underwater acoustics 99**
4. **Signal processing in acoustics 80**
5. **Acoustical imaging 51**
6. **Railway acoustics 37**
7. **Engineering in acoustics 35**
8. **Structural vibration & acoustics 31**
9. **Acoustical metamaterials 26**
10. **Psychological acoustics 24**
11. **Musical acoustics 19**
12. **Ultrasonics 18**
13. **Speech communication 18**
14. **Physical & biomedical acoustics 11**
15.

VI. BID FOR FUTURE INTERNATIONAL CONFERENCES

Riding on the success of Wespac 2015, the society is bidding to host the International Congress on Acoustics(ICA) in Singapore in 2025 and to host the

International Congress on Sound and Vibration(ICSV) in Singapore in 2021 and the InterNoise in Singapore in 2023.

Government Bodies

www.mom.gov.sg

www.nea.gov.sg

www.lta.gov.sg

Technical and Research Sites

Corporate Sites

www.metaultrasound.com

www.noisecontrols.com

(The Society welcomes interested parties to contribute relevant websites to the above e useful links. For more information, please contact us. Thank you.)

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