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E-NEWSLETTER

July 2013 ISSUE

THE SOCIETY OF ACOUSTICS SINGAPORE

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Registration No: 0331/1989
Year of Registration: 1989

CONTENTS

I CONFERENCE NEWS

Fellow members of the Society may like to take note of the following:

20th International Congress on Sound and Vibration(ICSV20)

Date: 7-11 July 2013

Venue: Bangkok, Thailand

Closing date for the abstracts: 31st Jan 2013

Notification of Acceptance: 28 February 2013

Deadline for Full-Length Paper: 1 April 2013

Deadline for Early Registration: 1 April 2013

For more information, please visit: www.icsv20.org

Please note that Society of Acoustics(Singapore) has the honour to be the cooperating society of ICSV20. Hence all members of the Society of Acoustics(Singapore) will be given a reduction of $50 USD from the conference registration fee.

Also Dr W S Gan will be organising two structured sessions for ICSV20 on:(i)Nonlinear acoustics and vibration, (ii)New acoustics, based on metamaterials. The closing dates for the 500 words abstracts is 31st Jan 2013. Kindld send abstracts directly to: wsgan@acousticaltechnologies.com.

II. Report on 2013 ICU Singapore and AI32 by Woon Siong Gan

The 2013 International Congress on ULtrasonics took place in the Grand Copthorne Waterfront Hotel Singapore from 2 – 5 May 2013. It was organized by the Society of Acoustics(Singapore). Supporting organizations were International Commission on Acoustics, Australian Acoustical Society, Acoustical Society of India, Hong Kong Institute of Acoustics & Indian Society of Nondestructive Testing. 2013 ICU provided an excellent opportunity for exchanging ideas on all the exciting current developments in ultrasonics and connecting with colleagues in the field. It brought together 250 registered delegates, including 83 students from 38 different countries. The top few most represented countries in order of the number of papers presented by their delegates were China, Japan, France, Germany, UK, Russia, Brazil, USA, Korea, India, Switzerland, Belgium and Italy.

2013 ICU was wide-ranging in its coverage of the field of ultrasonics, threading together the many directions the field has taken, from fundamental sciences to engineering and to biomedical applications, from traditional areas such as non-destructive testing (NDT) and ultrasonic imaging to a host of "hot topics", such as acoustical metamaterials, particle manipulation, high intensity focused ultrasound (HIFU) for therapy, puicosecond laer ultrasound and THz acoustic lasers(Sasers). The conference was well structured, with 9 plenary keynote addresses on a variety of topics, parallel oral sessions covering a wide range of topics,special organized sessions on selective topics and a poster session.

The plenary addresses were in brief:

Therapeutic ultrasound by Larry Crum
Metallic glasses by Walter Arnold
Acoustic metamaterials by Ping Sheng
HIFU by Boo Cheong Khoo
Sasers by Boris Glavin' Nanoultrasonics by Ch-Kuan Sun
Phononics by Baowen Li
Tissue Viscoelasticity by James Greenleaf
There were special sessions on: Picosecond laser ultrasound(organized by Oliver Wright and Vitali Gusev)
High power ultrasound (Enrique Riera)
Ultrasound microtechnology and particle manipulation (David Hutchings and Arian Neild)
Ultrasonic motors & actuators (Kentaro Nakamura)
Therapeutic ultrasound (Yufeng Zhou)
Bubble dynamics & cavitation (Claus-dieter Ohl)

The 32nd International Symposium on Acoustical Imaging (AI32) was held at the Civil Service Club Singapore from 29 April to 1st May 2013. It was successfully held with some 40 participants from 13 countries with the largest number of papers from Japan and UK and many young researchers. There were seven plenary keynote addresses. A wide range of topics were covered: physics and mathematics of acoustical imaging, nondestructive testing, medical ultrasound, acoustic microscopcy, acoustical metamaterials, underwater aqcosutics, elasticity imaging, transducers and arrays and methods in ultrasonography.

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: wsgan@acousticaltechnologies.com

Application form: ( ) Member ( ) Associate

1) Name: ____

2) Address: ____

Fax: ______________________ E-mail: ____________________________

3) Degrees (Institutions and dates):

____

4) Employment (with dates):

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5) Signature & Date: ____

IV. ARTICLES

Acoustic Radiation Force in Microfluidic Devices

Lim Kian Meng
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Introduction

Acoustophoresis is the phenomenon of movement of particles, such as microspheres and biological cells, in a sound field via the acoustic radiation force. This force is a second order, time-averaged force that acts on suspended particles in a sound field. For a sphere of radius *R* in a standing wave with wavenumber *k* in the *x*-direction, the force *F* in the *x*-direction is given by the following formula.

$$F = -\frac{4}{3}\pi R^3 k E \beta \sin(2kx)$$

Here, *E* is the acoustic energy density and *x* is the distance from a pressure node. The direction and strength of the acoustic radiation force are characterized by the acoustic contrast factor β, which is a function of the densities (ρ_s and ρ_f) and compressibilities (κ_s and κ_f) of the sphere and surrounding fluid.

$$\beta = \frac{5\rho_s - 2\rho_f}{2\rho_s + \rho_f} - \frac{\kappa_s}{\kappa_f}$$

When the acoustic contrast factor is positive, the acoustic radiation force pushes the sphere to the pressure node of the acoustic standing wave. When the acoustic contrast factor is negative, the acoustic radiation force pushes the sphere to the pressure antinode of the acoustic standing wave (Figure 1).

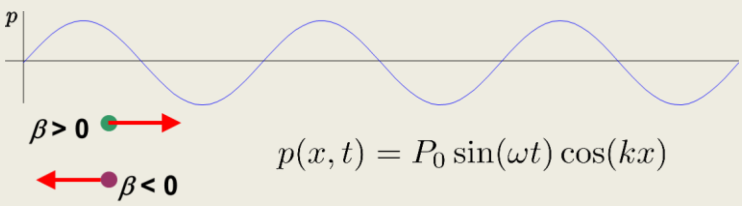
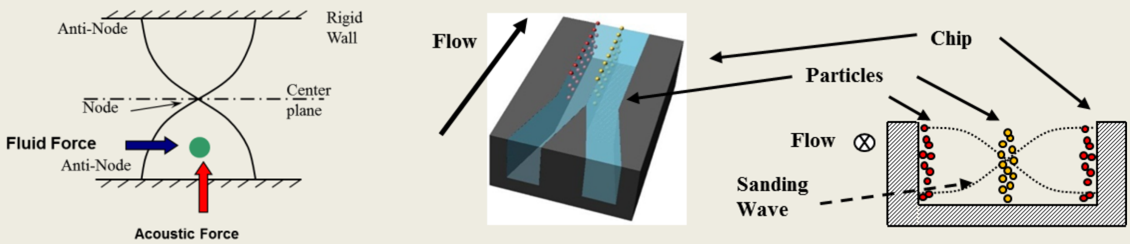


Figure 1. Illustration of force acting on spheres in a standing wave. Spheres with positive contrast factor β are pushed to the pressure node, while spheres with negative contrast factor β to the pressure antinode.

Typically, an ultrasonic standing wave is set up in a microfluidic channel (Figure 2), and suspended particles will be pushed to the pressure node or antinode of the channel, depending on their acoustic contrast factors (positive or negative).

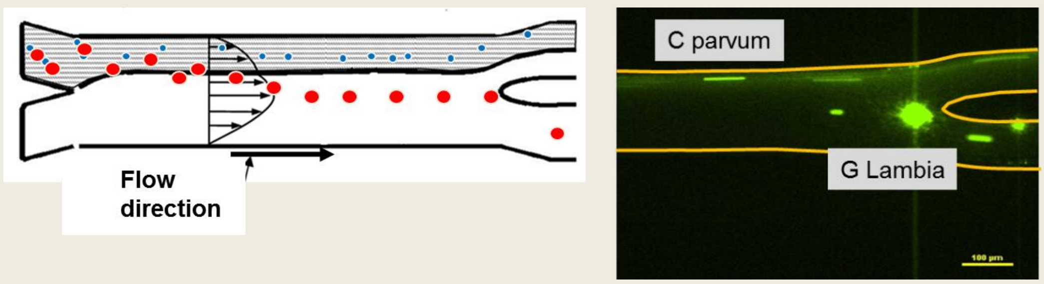


(a) (b)

Figure 2. Standing wave is set up across the width of a microfluidic channel. Spheres or cells of opposite contrast factor can be separated by pushing them to the pressure node and antinode.

Cell separation

We had carried out experiments to demonstrate the manipulation of microsized particles using this acoustic radiation force. These experiments were conducted on polystyrene microspheres and some biological cells. The schematic of the setup and experimental observation are shown in Figure 3.



(a) (b)

Figure 3. (a) Schematic showing the separation of spheres or cells using the different strength of acoustic radiation force due to size effect. (b) Experimental observation of separation of two species of cells of different sizes.

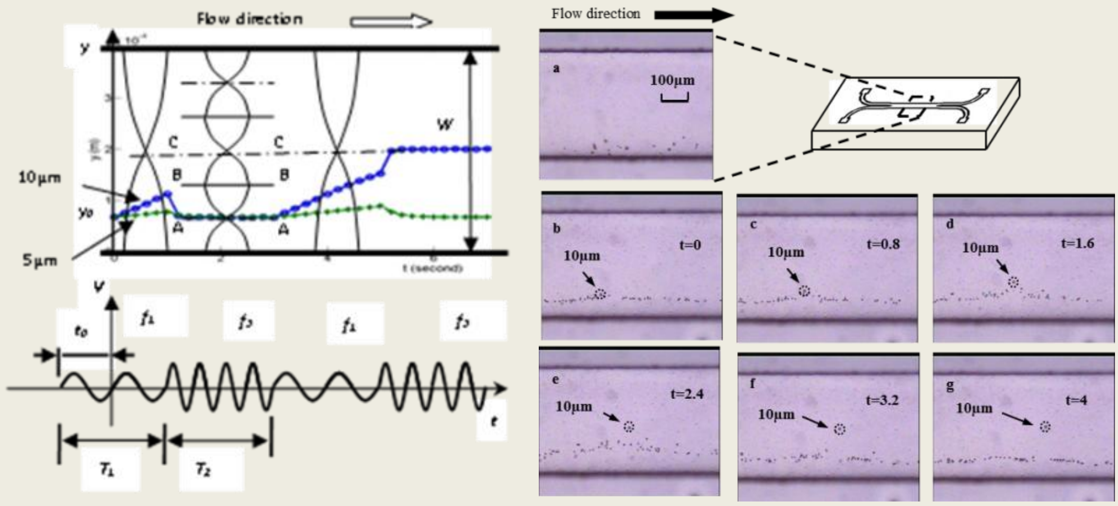
By controlling the relative flow rate of the two inlets, the interface between the two fluid streams within the channel can be shifted from the pressure nodal line. When polystyrene microspheres or cells flow through the acoustic standing wave, the ones that experience a sufficiently large acoustic radiation force will be transported across the interface from the original fluid medium into the other parallel stream. Since the magnitude of the acoustic radiation force on a sphere is proportional to the volume of the spheres, spheres with the same acoustic contrast factor but different sizes can be separated (Figure 3a). The larger spheres will move faster to the pressure node than the smaller ones. With proper sizing of the microchannel, volume flow rate and the acoustic field strength, spheres or cells of different sizes can be separated at the end of the micro channel.

The experiment was also conducted with two species of waterborne parasites, *Giardia lamblia* and *Cryptosporidium parvum*. Typically, the *Giardia lamblia* are larger (15µm) than the *Cryptosporidium parvum* (5µm). Under the action of the ultrasound field, the larger *Giardia lamblia* were transported from the upper stream of deionized water to the lower stream of PBS buffer and collected at the lower outlet (Figure 3b). The smaller *Cryptosporidium parvum* continue to flow within its original stream of deionized water.

Switching ultrasound field

The separation process can be enhanced by applying a time modulation to the acoustic radiation force. In this respect, we make use of an ultrasonic standing wave that switches between the first and third mode to separate polystyrene microspheres of two different sizes.

The operating principle of our design is illustrated in Figure 4a. The spheres are first focused near the lower nodal line [A-A] of the third mode. When the standing wave is switched to the first mode, the spheres move towards the center node [C-C]. Larger spheres experiencing a larger acoustic force move faster than the smaller ones. The third mode is switched back on before the smaller spheres cross the anti-node barrier [B-B] midway between the two nodal lines. The larger spheres would have crossed the barrier [B-B] when the third mode is switched back. Hence, the larger spheres stay on nodal line [C-C], which remains as a nodal line for both the first and third modes. After several cycles of switching between the first and third modes of the standing wave, the large and small spheres are effectively separated on two sets of nodal lines.



(a) (b)

Figure 4. (a) Schematic showing the trajectories of spheres of different sizes under the switching mode-1 and mode-3 standing waves. The spheres are injected near the lower pressure node of mode-3. (b) Snapshots of sphere motion under the switching ultrasound field. The larger 10µm sphere is pushed towards the central pressure node and separated from the rest of the smaller 5µm spheres.

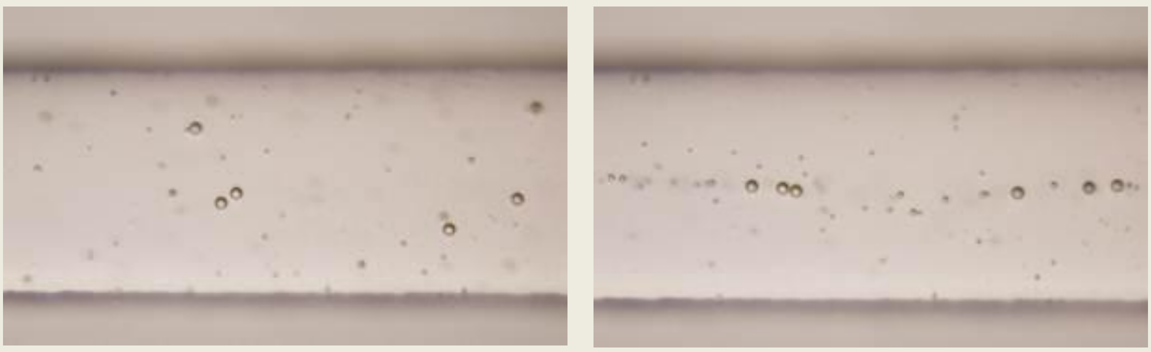
Figure 4b shows the snapshots of the spheres at different time (Panels b to g). The larger 10µm sphere is identified (as shown in a circle) and traced. It can be seen that it is moved to the center node of the channel while smaller 5µm spheres remain at the lower node.

Cell stiffness measurement

The microfluidic chamber can also used to measure the bulk modulus or stiffness of cells. This is done by comparing the cell trajectory against a numerical model. A mixture of the cells and polystyrene spheres was first injected into the microchannel. The ultrasound standing wave is then applied, and the trajectories of the cells and spheres are observed under the action of the acoustic radiation. Since the material properties of the spheres are known, their trajectories were used to determine acoustic energy density. With this energy density known, the stiffness of the cells can be determined.

The process to determine the acoustic energy density or cell stiffness is based on fitting the experimental trajectories with numerical simulations. The unknown parameter, energy density or cell stiffness, is used as the fitting parameter so that the difference between the experimental and simulation trajectories is minimized.

Figure 5 shows the experimental observation of 3µm, 5µm and 10µm polystyrene spheres suspended in water in a microchannel. When no acoustic radiation was applied, we observed that the spheres are scattered randomly. However, when the ultrasonic standing wave was applied, we observed that the spheres moved towards the centre of the channel, forming a straight line along the pressure node in the middle of the channel. The movement of the spheres was recorded and used as the reference trajectories for parameter fitting in the numerical model. The acoustic energy density was estimated to be 0.23 J/m^3. Examples of the experimental and simulated trajectories are shown in Figure 6.



(a) (b)

Figure 5. Polystyrene spheres suspended in microfluidic channel. (a) Spheres are scattered in the channel when no ultrasound field is applied. (b) Spheres move to the pressure nodal line at the center of the channel when a standing wave is set up.

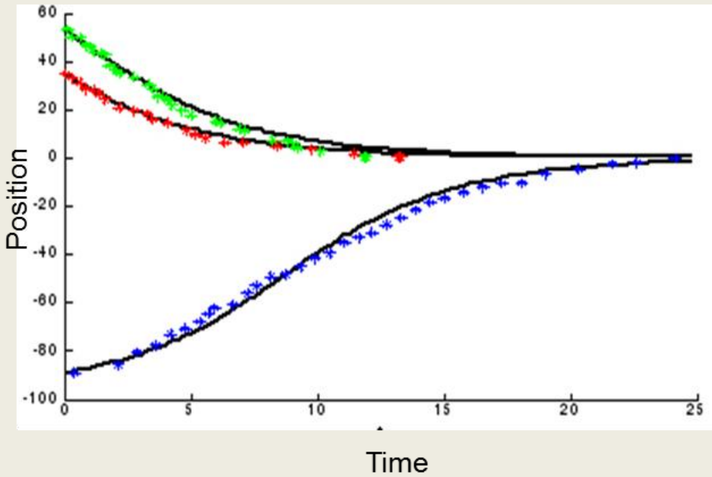


Figure 6. Experimental (dots) and simulated (line) trajectories of 5µm polystyrene spheres. The fitting parameter is found such that the difference between the two sets of trajectories is minimum.

The experiment was repeated with the spheres and red blood cells. Knowing the acoustic energy density from the trajectories of the spheres, the compressibility of the red blood cells was calculated to be $3.31 \pm 0.22 \times 10^{-10}$ Pa^{-1}. The homogenized bulk modulus is estimated to be 3.02 GPa.

Conclusion

In this article, the use of ultrasound standing wave in microfluidic channels had been described. The acoustic radiation force acting on suspended microspheres or cells can be used to separate the spheres or cells by size. In addition, the stiffness or compressibilities of cells can be estimated by fitting the experimental trajectories of the cells with a numerical model.

References

1 Liu Y., Hartono D. and Lim K.M. (2012) “Cell Separation and Transportation between Two Miscible Fluid Streams Using Ultrasound” *Biomicrofluidics*, 6, Article 012802.

2 Hartono D., Liu Y., Tan P.L., Then X.Y.S., Yung L.Y.L and Lim K.M. (2011) “On-Chip Measurements of Cell Compressibility via Acoustic Radiation” *Lab on a Chip*, 11, pp 4072--4080.

3 Liu Y. and Lim K.M. (2011) “Particle Separation in Microfluidics using a Switching Ultrasonic Field” *Lab on a Chip*, 11, pp 3167--3173.

SPEECH INTELLIGIBILITY FOR SOUND SYSTEM

Diagrams and charts courtesy of Philips Electronics, Eindhoven, Holland.
by Sonny Lim January 2010

We live in an environment full of sound and noise; very often we take them for granted. There are varieties of sound either clear or muffled, articulate or garbled, very often we are ignorant to the fact until it is experienced personally to realise the importance of clear intelligible sound.

This brief explanation will help us to understand better on the advantage of having a good sound over a poor one. Money is being spent in installing sound systems without any significant consideration given if the speech and announcements are getting through to the listeners. Often with sound systems, spoken words cannot be easily understood and at times can be more of an irritant than aid in audibility.

Sound reproduction is being influenced by two factors:

1) Room Acoustics – this is measured in terms of time delay for the sound to be reflected and decayed within a confined space.

2) Audio System – this is determined by the sound pressure level, frequency alignment and distortion present in the amplified sound.

Under ideal condition, a room with good acoustics and sound system will reproduce amplified sound that is life-like, audible and intelligible which can be easily heard and understood without much difficulty.

Room Acoustics

The room acoustics must be of acceptable reverberation time factor or sound treatment can be added to improve it to the best possible figure.

Audio System

The audio system, if installed, must be competently configured and the tonal equalisation precisely aligned as to reduce disturbing and highly reverberant frequencies.

Psychoacoustics in Sound System Design

To understand speech intelligibility, we have to involve the human psycho-logical aspects of hearing for the study. Our brain has certain limitation in perceiving and understanding spoken words, which can be affected by words articulation or distraction by extraneous influence, such as room echoes, fan and surrounding noises.

Acoustics can greatly influence the reverberation time in rooms and halls and if the sound system is not properly aligned, these factors will compound and seriously affect the amplified speech intelligibility on spoken words.

Poor acoustics will generate high indirect sound in rooms and halls causing multiple repetitive echoes of the original audio signal. If this interference is not properly dampened or controlled they will saturate the room making spoken words either unintelligible or difficult to understand. This is described in psyco-acoustics term as Loss of Consonants. The quantum is measured from a series of 100 spoken words and assessing how many words are "lost" or unintelligible.

That is why the emphasis must be given to sound system design on the Loss of Consonants or in short Alcons. This exercise will allow accurate assessment of the speech intelligibility in direct relation to the room acoustics and sound system installed.

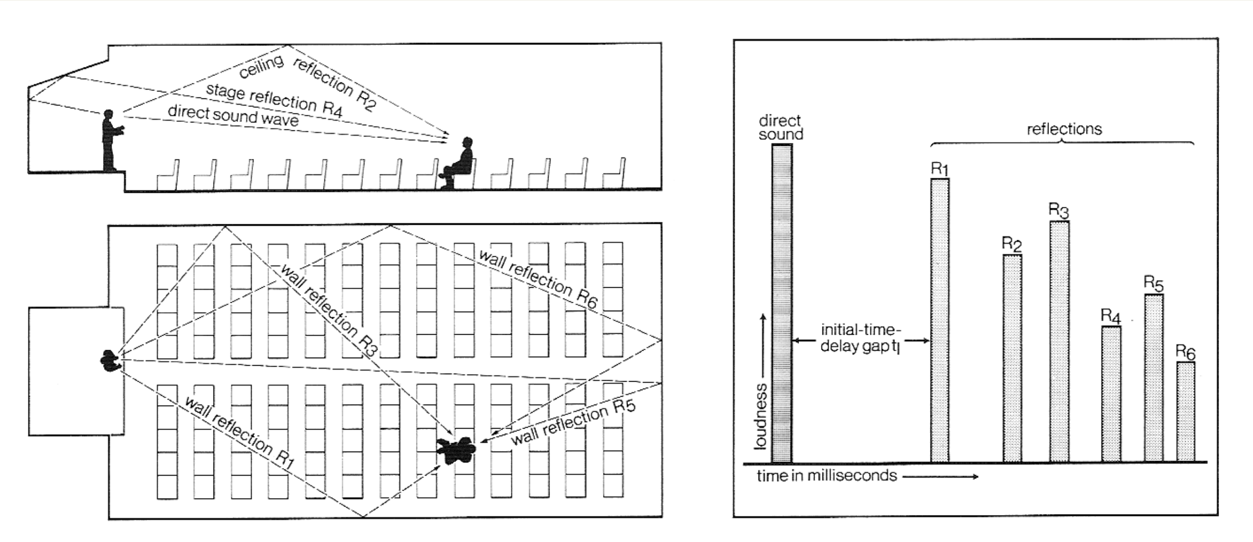


Figure 1- REFLECTED SOUND WAVES

Measurements of articulation Loss of Consonants (AL_C) are defined as follows:

AL_C <10%	Speech Intelligibility is adequate even for complicated messages involving untrained speakers and listeners.
AL_C =15%	Speech intelligibility adequate for less complicated messages for untrained speakers or listeners, but still adequate for complicated messages in a clear and well articulated speech.

AL_C >15% - <30%	Speech intelligibility generally adequate only for simple messages; for complicated messages only for trained speakers and listeners.
AL_C >30%	Limit of acceptable speech intelligibility even for trained speakers and listeners even for simple messages.

Generally for a good acoustics and sound system design for any lecture room or meeting hall the AL_C must not exceed 10%. This is to prevent fatigue in the brain from having to concentrate and process the spoken words received by the ears. For public places, like shopping complexes and airports the AL_C must not exceed 15% when operated by trained personnel; this is to ensure voice paging announcements can be clearly understood.

To provide graphical relationship between these three parameters i.e. **$AL_{C\ direct}$, AL_{Cdif}** and **RT 60** the following chart has been prepared for easy visual understanding.

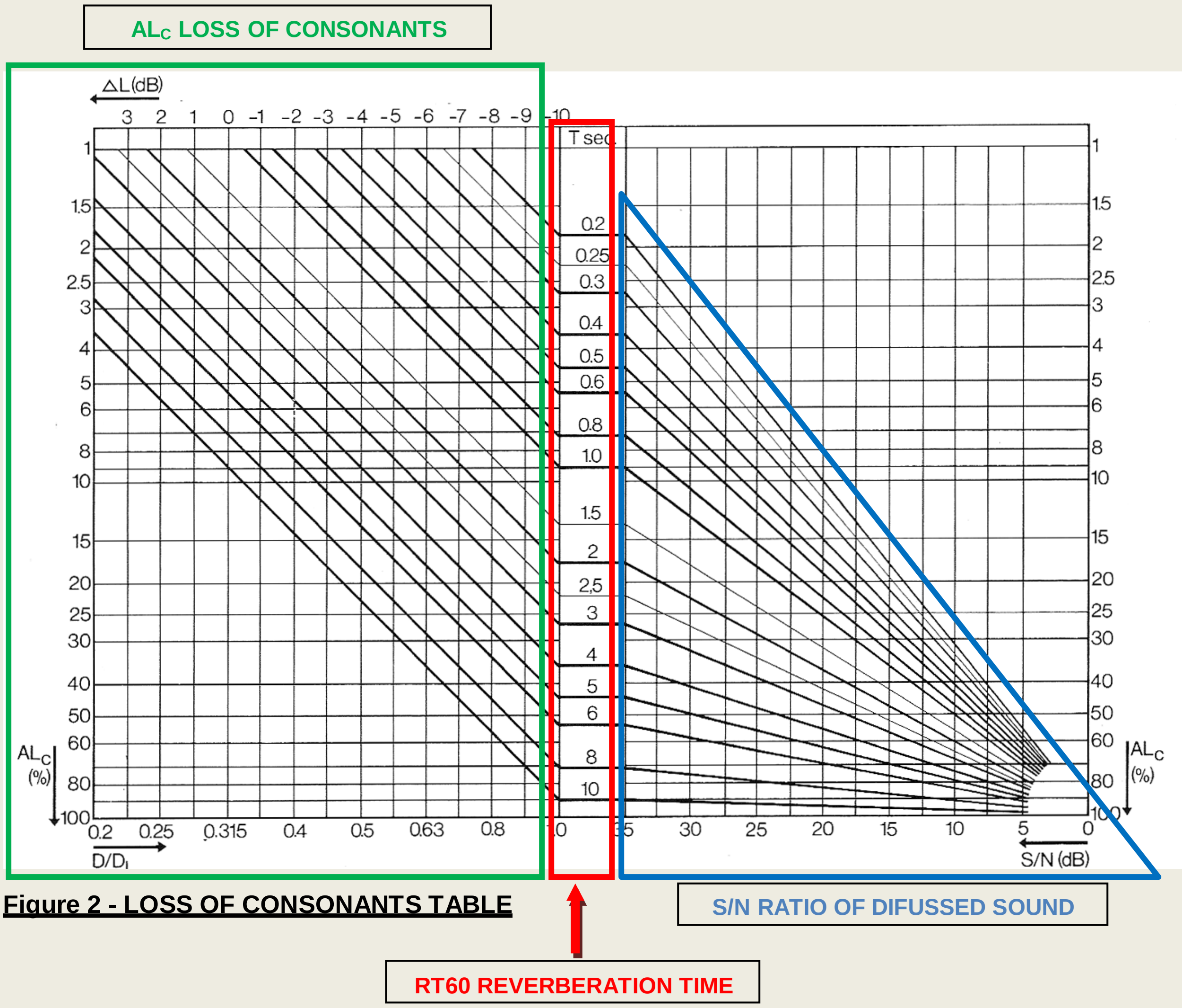


Figure 2 - LOSS OF CONSONANTS TABLE

From the three parameters, they clearly indicate that when the direct sound is exceeded by the indirect sound relative to the reverberation time, the Loss of Consonants (AL_C) percentage increases, causing the speech intelligibility to suffer. The exact value for Loss of Consonants AL_C can be graphically determined by plotting the graphical lines of the three governing factors.

It is imperative that when designing any sound system the Loss of Consonants must always be taken into consideration to ensure intelligibility on spoken words and announcements. A poorly designed sound system, can only be realised when disasters happen, during emergency like fire and evacuation announcement messages may not be easily understood and responded in time.

V. RESEARCH NEWS

A temporal cloak at telecommunication data rate

Joseph M Lukens, Daniel E Leaird & Andrew M Weiner, Nature/Letter, published online 05 June 2013

Through advances in metamaterials – artificially engineered media with exotic properties including negative index, the once fanciful invibility cloak has now assumed a prominent place in scientific research. By extending these concepts to the temporal domain, investigators have recently described a cloak which hides events in time by creating a temporal gap in a probe beam that is subsequently closed up : any interaction which takes place during this hole in time is not detected. However, these results are limited to isolated events that fill a tiny portion of the temporal period, giving a fractional cloaking window of only about 10^{-4} per cent at a repetition rate of 41 kilohertz – which is much too low for applications such as optical communications. Here we demonstrate another technique for temporal cloaking which operates at telecommunication data rates and by exploiting temporal self-imaging through the Talbot effect hides optical data from a receiver. We succeed in cloaking 46 per cent of the entire time axis and conceal peusorandom digital data at a rate of 12.7 gigabits per second. This potential to cloak real world messages introduces temporal cloaking into the sphere of practical application with immediate ramification in secure communications.

VI. USEFUL LINKS

Bodies

www.mom.gov.sg

www.nea.gov.sg

Technical and Research Sites

Corporate Sites

www.acousticaltechnologies.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.)

President: Dr. Gan Woon Siong
E-Newsletter compiled by: Dr. Tan Kok Yang and Dr Gan Woon Siong