Proceedings of

The Sixth Green's Function Seminar

18 June 2016, Shanghai, China

Edited by Dong-Qiang Lu

Shanghai Key Laboratory of Mechanics in Energy Engineering,

Shanghai Institute of Applied Mathematics and Mechanics,

Shanghai University

上海大学 上海市应用数学和力学研究所

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Organsing Committee for the Sixth Green's Function Seminar

Dong-Qiang Lu (Shanghai University, China) **Mobile phone: 180 1706 0057**

Xiaobo Chen (Bureau Veritas, France)

The cover picture: Green's Mill in Sneinton, the mill owned by Green's father. The mill was renovated in 1986 and is now a science centre.

This picture is downloaded from https://en.wikipedia.org/wiki/George_Green_(mathematician)

Green's Function Seminar

Green's Function Seminar (GFS) is informal, aiming at exchanging knowledge, experiences and opinions of scientists and professionals working in the highly specialized field of Green's function and its application.

The seminar is by invitation only.

The GFS was initiated by Prof. Xiaobo Chen of Bureau Veritas (France), Prof. Wenyuan Duan of Harbin Engineering University (China) and Prof. Ernian Pan of The University of Akron (USA). The first GFS was held in Harbin Engineering University on 9 July 2011. Since then four annual seminars were successively held in Dalian (2012), Weihai (2013), Zhengzhou (2014), and Jeju, Korea (2015).

The Sixth GFS (GFS'2016) will be held in Shanghai on 18 June 2016, and is organized by Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University, China. There are **19** lectures with short abstracts will be presenting in the GFS'2016. About **38** participants from **15** universities / research institutions in China, France, Korea, and Singapore will be taking part in this seminar.

History of the Green's Function Seminar

No.	Date (Y.M.D)	Place	Host	Organizer
1	2011.7.09	Harbin, China	Harbin Engineering University	Wenyuan Duan
2	2012.8.10	Dalian, China	Dalian University of Technology	Zhi Zong
3	2013.5.25	Weihai, China	Harbin Institute of Technology at Weihai	Yu-Zhi Dai
4	2014.8.11	Zhengzhou, China	Zhengzhou University	Ernian Pan
5	2015.9.18	Jeju, Korea	Pusan National University	Sun-Hong Kwon
6	2016.6.18	Shanghai, China	Shanghai University	Dong-Qiang Lu

Supporting Journal

The Editor-in-Chief of *Applied Mathematics and Mechanics (English Edition)* (AMM), Professor Xing-Ming Guo (郭兴明) (Standing Deputy Head of Shanghai Institute of Applied Mathematics and Mechanics), would like to invite all the presenting and corresponding authors of the GFS'2016 to submit their full manuscripts for possible publication in AMM. A rapid peer-review process is guaranteed.

Applied Mathematics and Mechanics (English Edition), with ISSNs 0253-4827 (Print) and 1573-2754 (Online), is a comprehensive journal presenting original research papers on mechanics, mathematical methods in mechanics as well as applied mathematics relevant to neoteric mechanics. Founded by Prof. Weizang Chien (钱伟长) in May 1980 as a quarterly, AMM became a bimonthly in 1981 and then a monthly in 1985. It is included by the Engineering Index (EI) from 1990 and by the Science Citation Index Expanded (SCI-E) from 1997. During the years of 2008 to 2014, the Impact Factor (IF) of AMM in the Journal of Citation Report increases from 0.340 to **1.128**.

For more details on AMM or the full texts of the articles, please refer to

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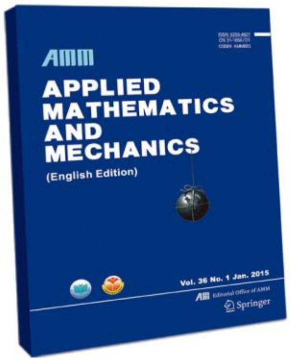

Introduction to SIAMM

Shanghai **I**nstitute of **A**pplied **M**athematics and **M**echanics (SIAMM) was found on 1 November 1984 under the approval of the State Science and Technology Commission of China. Professor Weizang Chien, a renowned scientist in mechanics and applied mathematics, served as the first Head of SIAMM from 1984 to 2010. The research at SIAMM covers nearly all the directions in fluid mechanics and solid mechanics. The applied mathematics research mainly concerns mathematical methods for complex mechanics problems. Currently SIAMM has about 40 faculty members and about 200 postgraduate students. For more details, please refer to

http://siamm.shu.edu.cn (in Chinese)

Registration Information

Registration Day:	17 June 2016 (Friday), 2:00PM--8:00PM
Seminar Day:	18 June 2016 (Saturday)
Registration Place:	Lehu Hotel (149 Yanchang Road, Shanghai, China)
Address in Chinese:	**上海 闸北 延长路 149 号 上海大学 乐乎楼**

Accommodation

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Baoshan Campus, Shanghai University

Technical Program

17 June 2016 (Friday)

14:00–20:00	**Registration** Lehu Hotel Lobby 149 Yanchang Road, Jing'an, Shanghai	
18:00–19:00	**Dinner** Lehu Hotel	

18 June 2016 (Saturday)

Venue: 2nd Floor, SIAMM Building (149 Yanchang Road)

8:00–8:30	**Registration** 2nd Floor, SIAMM Building	
8:30–8:40	**Opening Ceremony**	Chaired by **D. Q. Lu**
8:40–9:10	**Weiqiu Chen** (Zhejiang University): Green's functions for a two-phase soft electroactive space under biasing fields and applications	Chaired by **Wenyang Duan**
9:10–9:40	**Xiaobo Chen** (Bureau Veritas): Green function (point solution) versus body solution	
9:40–10:10	**Ernian Pan** (The University of Akron): Some fundamental solutions in layered spherical structures	
10:10–10:20	**Photo-taking** at the Gate of the SIAMM Building	
10:20–10:40	**Coffee Break**	

10:40–11:10	**Bernard Molin** (Ecole Centrale Marseille): On approximations of the wave drift forces acting on semi-submersible platforms with heave plates	Chaired by **Zao-Jian Zou**
11:10–11:40	**Zhi Zong** (Dalian University of Technology): Green's function of three-dimensional vortex in the presence of free surface	
11:40–12:10	**Yu-Zhi Dai** (Harbin Institute of Technology): On the high order asymptotic expansion of Fourier integral with two nearly coincident saddle points	
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13:30-13:50	**Won-Joong Kim** (Pusan National University): Application of Green function technique to second order effect induced by a forced heaving truncated cylinder	Chaired by **Sun-Hong Kwon**
13:50-14:10	**Hui Liang** (Bureau Veritas): Dispersion relation and far-field waves for capillary-gravity wave	
14:10-14:30	**Shan Huang** (Harbin Engineering University): Practical algorithm of simplified Green function for steady ship waves	
14:30-14:50	**Huiyi Wu** (Shanghai Jiao Tong University): Practical Green function for wave diffraction radiation in deep water	
14:50-15:10	**Chao-Bang Yao** (Naval University of Engineering): Numerical and experimental study on hydrodynamic performance of a ship in finite water depth	
15:10-15:30	**Lei Sun** (Dalian University of Technology): An indirect BEM method to predict the wave-induced ship motions and loads with Haskind source Green function	
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16:10-16:30	**Xiaoping Lu** (Naval University of Engineering): A compound method for ship wave resistance calculation combining Green functions based on Rankine source and Kelvin source	Chaired by **Zhi Zong**
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17:30-17:50	**Dali Xu** (Shanghai Maritime University): Power balance for semi-infinite line arrays of wave energy converters	
17:50-18:05	**Muhammad Mubashir Bhatti** (Shanghai University): Head-on collision between two hydroelastic solitary waves under an ice sheet	
18:10-18:30	**Closing Ceremony and Free Discussion**	Chaired by **Xiaobo Chen**
18:35	**Dinner** at Lehu Hotel	

- **For a quick switch, please upload your presentation files before the section begins.**
- **At least five minutes is recommended for questions and answers in every presentation.**

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List of Abstracts

Head-on collision between two hydroelastic solitary waves under an ice sheet

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Head-on collision between hydroelastic solitary waves propagating at the surface of an incompressible and ideal fluid covered by an ice sheet has been analyzed. The ice-sheet is model with the help of the special Cosserat theory of hyperelastic shells and Kirchhoff's love plate theory, which yields the nonlinear and conservative expression for the bending forces. The resulting governing equations are solved asymptotically by means of the Poincaré-Lighthill-Kuo (PLK) method and the solutions up to the third order have been obtained. It is observed from the mathematical solutions that solitary waves after collision do not change their shape and amplitude. Furthermore, it is also noted that before collision, the wave profile is symmetric. However, after collision it becomes unsymmetric and titled backward in the direction of wave propagation.

Muhammad Mubashir Bhatti received his BS degree in Mathematics in 2011 from International Islamic University Islamabad Pakistan, and his MS degree in Applied Mathematics in 2013 under the supervision of Prof. Rahmat Ellahi of International Islamic University Islamabad Pakistan. In 2014, he became a PhD candidate under the supervision of Prof. Dong-Qiang Lu in Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University. His current research includes (i) Hydroelastic waves (ii) Perturbation methods, and (iii) Solitary waves.

Green function (point solution) versus body solution

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The Green function involved in free-surface potential problems represents a harmonic flow generated by a point source which satisfies the linear boundary condition on the free surface and the radiation condition at infinity. We like to refer it as the point solution. The point solution can be distributed on some surface (usually on the body surface) to form a complete solution which satisfies all boundary conditions on the body surface by using the boundary integral equation to determine the density of distribution, and is referred as body solution. The body solution can then be considered as a distribution of point solutions. Comparisons of different important properties embedded in the point solution versus the body solution are reported in this study.

The point solution can be obtained by applying the Fourier transform to differential equations of the problem in frequency domain and is then represented by a double Fourier integral. Associated with the boundary condition on the free surface, the integrand of the Fourier representation contains a denominator called dispersion function. By the asymptotic analysis given in Noblesse & Chen (1995), the wave component can be derived from the double Fourier integral and expressed by a single integral along the dispersion curves defined by the zeroes of dispersion function. The relationship between the dispersion curve on the Fourier plane and associated waves on the free surface has been established by applying the method of stationary phase to the single integral. Indeed, the wave length, and phase & group velocities are intrinsically linked to the wavenumber magnitude, wavenumber vector & normal vector along the dispersion curve. The crest-lines (at constant-phases) of waves can then be easily obtained. Furthermore, the cusp angles are determined by the normal direction at the inflection points of dispersion curve. Similarly, a time domain analysis based on Laplace-Fourier transform gives the point solution by a single Fourier integral associated with an impulsive point perturbation. Being a distribution of point solutions, the body solution is often stated to have the similar properties as those of the point solution. However, it is not true in most cases.

First of all, the point solution can be complexly singular and highly oscillatory in space such as the ship-motion Green function with forward speed when the source and field points are both approaching to the free surface, or waves near the origin of impulsive point are found to diminish continually in length and to increase continually in height. These peculiar properties are manifestly non-physique. The body solution should be totally different or at the least the leading terms (singularities and high oscillations) might be cancelled out due to destructive interference effect in the integration of point solutions according to Lamb (1916). The work by Liu & Yue (1993) showed that the body solution is well finite at the critical frequency related to the particular Brard number (tau=1/4) at which the point solution is singular and that the results (added mass, damping and wave loading) are continuous across the frequency (not critical at all). Other examples include the waves in the trapping modes and cloaking studies where the properties of body solution are totally different from those of point solution. The recent interesting works on ship wakes show that the wedge angle of wave crests behind the ship varies with the ship speed in contrary to the Kelvin angle which is derived from the point solution and independent of ship speed.

Furthermore, the point solution (Green function) is not directly useful. Its usefulness is embedded in the boundary integrals which construct the basis of so called boundary element methods. However, the numerical evaluation of the point solution and its integration on the meshed boundary surface are very difficult, if not impossible, to obtain. In fact, the integration of point solutions over a meshed panel or along a line segment constructing the building block (influence coefficients) of the integral equations, inherits the similar singularity and oscillatory properties. In the limit of smaller and smaller panels (shorter and shorter segment), the integral equation should be more and more ill-conditioned and could not produce correct and convergent results. As mentioned above, the point solution cannot represent the body solution and is difficult to use in classical boundary element methods.

In order to overcome above difficulties, we first consider a body with smooth hull surface such as a hemi-ellipsoid, a hemi-sphere, a truncated vertical cylinder with bottom or an infinite vertical cylinder in deepwater. In the case of an infinite vertical cylinder, we can write the velocity potential and its radial derivative by an expansion composed of Fourier series in polar direction and Laguerre function in vertical direction.

The influence coefficients in the integral equation are then associated with all elementary Fourier-Laguerre distribution and represented by six-fold integrations including the double integration on the control surface of the Green function (represented by a double Fourier integral) and the double integral following Galerkin collocation. The six-fold integrals have been analytically calculated and reduced to single integrals in wavenumber. Furthermore, the single wavenumber integrals could be evaluated semi-analytically and approximated by Tchebychev polynomials. The body solution is then decomposed to a series of elementary solutions which are all a smooth distribution of point solutions and evaluated in an analytical way. Unlike the point solution, these elementary body solutions have similar behaviour like the body solution since the singularity and oscillation of leading orders in the point solution are just removed by the integration of a smooth distribution over a smooth space.

We have been developing a new multi-domain method based on dividing the fluid domain by a control surface surrounding floating bodies and being at some distance. The above elementary body solutions in the external domain from the control surface provides a relationship between the velocity potential and its radial derivative which we call as the Dirichlet-to-Neumann [DtN] operator. This [DtN] operator can be directly used in the coupling, through continuous conditions on the control surface, with the internal domain in which we use the Rankine source (1/r) to solve linear potential problems. The extension could be to couple with a CFD solver of viscous flows or non-linear potential flows in the internal domain. In this case, a transient domain between the external and internal domains is necessary to make a smooth transition from viscous or/and non-linear problem to the linear free-surface wavy problem. In this new multi-domain method, the numerical algorithms used in CFD are well suited for local flows in the vicinity of bodies while the semi-analytical solutions ensure the wavy behaviour of free-surface flows to be consistent and accurate.

Xiaobo Chen has graduated with distinction from Tsinghua University (China) in 1983. In 1988, he obtained a Ph.D in Hydrodynamics at the Ecole Centrale Nantes (France). After achieving his post-doctoral fellowship from Institute Francais du Petrole, he joined Bureau Veritas in 1991. He has worked successively as a research engineer in BV's Ocean Technology Department and in the Research Department of the Marine Division, Head of the Hydrodynamics & Mooring Section, Director of International R&D Cooperation, and now Director of Deepwater Technology Research Centre in Singapore. He has been a member of the IACS working group WD-SL and the ISSC Technical Committee on Loads, and chaired the recent IACS-HPT01 working group on harmonisation of the Common Structure Rules. Since 2006, he has been working under a professorship with Harbin Engineering University, and he has been Adjunct Professor of The University of Western Australia since 2010.

Throughout this period he has been very active in the theoretical research of free surface flows and wave loading as well as applications to the sea-keeping assessment of FPSOs, semi-submersibles, containerships, LNG carriers and high-speed vessels. He has written over a hundred technical papers for presentation to major international conferences and publication in a variety of industry publications, including the Journal of Fluid Mechanics, Journal of Engineering Mathematics, Journal of Ship Research, Ship Technology Research, and Marine Structure. His original contributions include the middle-field formulation for the computation of second-order wave loads and the analytical features of unsteady ship waves. Furthermore, the HydroStar software was developed during the course of his Ph.D studies and has been continually enhanced during his time at Bureau Veritas so that it is now widely regarded in the offshore industry and routinely used by more than forty companies to evaluate first-order and second-order wave loading and vessel response.

On the high order asymptotic expansion of Fourier integral with two nearly coincident saddle points

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Further to the uniform asymptotic expansion of Fourier integral with large parameter and with two nearly coincident saddle points presented at the workshop by Dai and Chen (2013), we have also obtained the higher-order non-uniform asymptotic expansions. These can be regarded as the generalization of Kelvin and Peter's result. This expansion is used to the analysis of Kelvin waves and compared to Peter result and showed its validity.

The nonuniform asymptotic expansion gives important information of the physical behaviour of this Fourier integral in different regions. Uniform asymptotic expansions can be used as the basis of its numerical approximations. Combination of these two results provides the complete solution to the problem proposed by Lord Kelvin.

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Practical algorithm of simplified Green function for steady ship waves

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The theory of steady ship waves is the fundamental problem of ship hydrodynamics. Steady waves generated by a point source under linear free surface condition have been studied for over one hundred years. While the numerical algorithm foe the steady wave Green function has been studied by many hydrodynamic researcher. It is still difficult to be used for practical ship generated wave prediction. Noblesse put forward a simplified Green function for diffraction-radiation of time-harmonic waves with forward speed in 2004. This method can be used to steady waves, diffraction-radiation waves and the combination of these two problems. It describes point source generated waves accurately at relative far distance from the source. But it hasn't attracted attention for a long time and the present study is to look for this practical way.

The paper has studied the steady ship wave Green function. The steady flow generated by a point source submerged below the free surface advancing at a constant speed in calm water is considered. The analysis of the velocity potential of the flow gives the practical numerical algorithm of the Green function, including the zone length and width compared to the ship length. The parameter analysis of the integral limit, the division of integral interval and the depth of the source is implemented. This gives the calculation parameters corresponding to different field point for both velocity potential and gradient of velocity potential.

Green's functions for a two-phase soft electroactive space under biasing fields and applications

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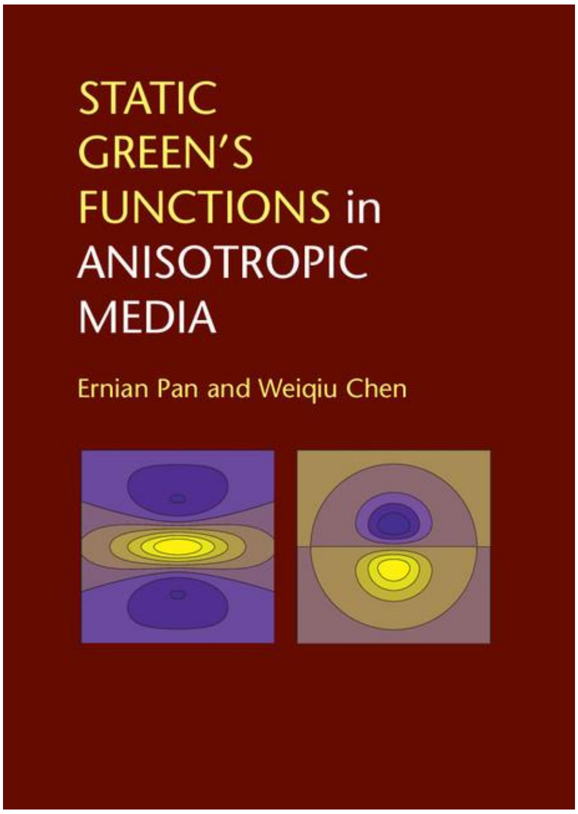
The problem of a point force and/or a point charge applied in the interior of an infinite two-phase soft electroactive space is considered. The space consists of two perfectly or smoothly bonded electroactive half-spaces, each being initially subjected to an arbitrary multi-directional stretch and a biasing electric field. Based on a linearized incremental theory for the deformation due to the point force and/or point charge, we derive a concise general solution to the governing equations. It is expressed in terms of quasi-harmonic functions, the forms of which for the problem considered can be obtained by the trial-and-error method, which the involved constants determined from the conditions on the perfect or smooth interface as well as some other considerations. As special cases of the present two-phase Green's functions, the generalized Mindlin solution and Lorentz solution (and the generalized Boussinesq solution and Cerruti solution as well) for an electroactive half-space subjected to an initial biasing field are discussed. In particular, the generalized Boussinesq solution is employed to solve the normal contact problem of a rigid sphere indenting a soft electroactive half-space.

Weiqiu Chen received his Ph.D. degree in Solid Mechanics from Zhejiang University in 03/1996. Since then, he has been with Zhejiang University as a lecturer (1996), associate professor (1999) and full professor (2000). He is now a Professor at Department of Engineering Mechanics, and serves the dean of the department. He has engaged himself in mechanics of smart materials/structures and vibration/waves in structures for more than twenty years. He is now particularly interested in mechanics of soft materials and structures. He has co-authored over 300 peer-reviewed journal articles and three English monographs: *Three Dimensional Problems of Piezoelasticity* (Nova, 2001), *Elasticity of Transversely Isotropic Materials* (Springer, 2006), and *Static Green's Functions in Anisotropic Media* (Cambridge University Press, 2015). He also has co-edited two English books, and seven English conference proceedings. He has been very active in collaboration with scientists from German, US, Japanese, and Korean universities.



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Application of Green function technique to second order effect induced by a forced heaving truncated cylinder

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In this paper, the 2nd order hydrodynamic force effect of heaving submerged circular cylinder is considered, with the linear potential theory. Boundary value problem (BVP) is expanded up to the 2nd order by using of the perturbation method and the 2nd order velocity potential is calculated by means of integral equation technique using the classical Green's function expressed in cylindrical coordinates. The method of solving BVP is based on eigenfunction expansions. With different cylinder heights and heaving frequencies, graphical results are presented. As a result of the present study, the cause of oscillatory force pattern is analyzed with the occurrence of negative added mass when a top of the cylinder gets closer to the free surface.

Hydroelastic wave resistance of a moving load on a floating thin visco-elastic plate

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The flexural-gravity (hydroelastic) wave responses due to a moving load with uniform or suddenly accelerated rectilinear motions are analytically studied within the framework of the linear potential theory. Very Large Floating Structures (VLFS) is modeled by a thin viscoelastic plate. The initially quiescent fluid in the ocean of finite depth is assumed to be homogenous, incompressible and inviscid, and the motion be irrotational. A moving line source on the plate surface is considered as a moving point in the two-dimensional coordinates, and the strength of the point is time-independent. Under the assumptions of small-amplitude wave motion and small plate deflection, a liner fluid–plate model is established. For the mathematical formulation, the Laplace equation is taken for the governing equation, representing the continuity of the mass. The dynamic condition on the fluid–plate interface indicates the balance among the hydrodynamic pressure of the fluid, the elastic and inertial forces of the plate, and external moving loads, which forms a hydroelastic problem.

The integral solutions for the surface deflections and the wave resistances are obtained by the method of the Fourier integral transform. To study the dynamic characteristics of the flexural-gravity wave resistances, the asymptotic representations of the wave resistance are derived by the residue theorem and the methods of stationary phase. It shows that the wave resistance is zero when the speed of moving load is less than the minimal phase speed. The wave resistances consist of two parts for the accelerate motion, namely the steady wave resistance and transient wave resistances. Eventually the transient wave resistance decline toward zero and the wave resistance approaches the steady wave resistance as the time goes to the infinity. Furthermore, the effect of the strain relaxation time for this viscoelastic plate is studied and it donates more influence for a high-speed motion.

Ji-Suo Li received his BSc degree in Marine Engineering in 2014 from Faculty of Maritime and Transportation, Ningbo University, and then seeks his master degree in fluid mechanics under the supervision of Prof. Dong-Qiang Lu in Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University. His current research is on hydroelastic wave and wave resistance due to concentrated loads moving on a thin plate floating on a fluid.

Dong-Qiang Lu received his BSc degree in Mechanics in 1995 from Fudan University and his MSc degree in Fluid Mechanics in 1998 under the supervision of Prof. Shi-Qiang Dai of Shanghai University. He worked as an assistant lecturer for one year at Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University before he went on pursuing a PhD degree in Marine and Offshore Engineering under the supervision of Prof. Allen T. Chwang at the Department of Mechanical Engineering, The University of Hong Kong. He returned to Shanghai University in 2003 and advanced to the full Professor rank in 2009.

At present, he is a member of the Committee of Fluid Mechanics in the Chinese Society of Theoretical and Applied Mechanics, a member of the Council of Singular Perturbation in the Chinese Mathematical Society, and the head of the Working Committee for Youths in Shanghai Society of Theoretical and Applied Mechanics. He serves as a member of Executive Editorial Committee for "*Journal of Hydrodynamics*" and "*Chinese Journal of Hydrodynamics*" (水动力学研究与进展). He also serves as Editorial Board members for "*Advances and Applications in Fluid Mechanics*," "*Chinese Quarterly of Mechanics*" (力学季刊) and other two English journals on applied mathematics.

His current research interests include (i) the generation of hydroelastic, gravity, and capillary-gravity waves due to moving bodies, (ii) the interaction between ocean waves and marine structures, and (iii) mathematical methods for analytical hydrodynamics.

A compound method for ship wave resistance calculation combining Green functions based on Rankine source and Kelvin source

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Present paper deduced a compound method for ship wave resistance quick calculation, using the Rankine source Green function to solve the ship hull surface's source density and combining with the Lagally theorem about source point force calculation based on the Kelvin source Green function to solve the wave resistance. In contrast of the thin ship method of the linear wave resistance theorem, this method has a higher precision, and in contrast of the method which completely use Kelvin source Green function, the method has a better computational efficiency. In general, the algorithm in this paper traded off the precise and efficiency of traditional calculation for wave making resistance.

Keywords: linear wave resistance, Green function, intensity of Rankine sources, intensity of Kelvin sources, direct boundary element method

Integration of time-domain Green function and approximations

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We consider the transient waves generated by an impulsive perturbation on an infinite vertical circular cylinder. On the cylindrical surface, the perturbation is expanded by a series of elementary perturbations composed of Fourier series in polar direction and Laguerre function in vertical direction. The waves generated by an elementary Fourier-Laguerre perturbation are then expressed by the memory integration of a double integration of the classical transient Green function associated with an impulsive source which is expressed by a wavenumber integral. The 5-fold integration is analyzed and then reduced to a single integral in wavenumber. Unlike the point Green function, the elementary solution by the integration of Green function with an elementary perturbation is non-singular and oscillatory of lower orders. The method of the steepest descents has been used to perform the asymptotic analysis of the single integral and to obtain analytical expressions at large time. Furthermore, the accurate and fast algorithms have been developed to evaluate the integration of time-domain Green function which are the critical building block of our new multi-domain method.

Ruipeng Li received his BE degree in Naval Architecture and Offshore Engineering in 2012 from Harbin Engineering University. He became a master student in 2012 and PhD student in 2013, both in Fluid Mechanics under the supervision of Dr. Xiaobo Chen in Harbin Engineering University. His current research interests include (i) Wave asymptotics, (ii) Transient potential flows, and (iii) Wave induced loads and ship motions.

Dispersion relation and far-field waves for capillary-gravity waves

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When a body like a ship or a pressure patch travels at a constant speed c at the air-water interface, free-surface waves are created. The far-field features of free-surface waves have been found in association with the dispersion relation (Noblesse & Chen 1995). The relationship between the dispersion curve on the Fourier plane and the corresponding wave pattern on the free surface has been established by applying the method of stationary phase (Chen 2004), and far-field waves with constant phase can then be easily obtained. Furthermore, the cusp angles of the wave pattern are determined by the normal direction of inflection points of dispersion curves.

In the present work, an asymptotic analysis on capillary-gravity waves generated by a traveling object is made through performing the stationary phase analysis on the dispersion function with an additional term of cubic wavenumber caused by the surface tension effect. Different from the open dispersion curve for pure-gravity waves, the dispersion curve of capillary-gravity waves is closed. At the minimum phase speed of capillary-gravity waves $c_{\min} \approx 0.23$ ms^{-1} (Lamb 1993), the dispersion curve reduced to an isolated point, and no waves are generated when $c \leq c_{\min}$. When the traveling speed is larger than $c_{\min}$, the closed dispersion curve is divided by a critical wavenumber k_σ, at which the wavenumber vector is tangent to the dispersion curve, into gravity-dominant and capillarity-dominant portions associated with the gravity-dominant waves appearing on the downstream at $k < k_\sigma$ and capillarity-dominant waves on the upstream at $k > k_\sigma$.

Besides the critical speed $c_{\min}$, we find a new speed threshold $c_{\text{fan}} = 0.45$ ms^{-1}. When the traveling speed is larger than c_{fan} , there exist two different inflection points k_1 and k_2 with $k_1 < k_2 < k_\sigma$ along the dispersion curve where gravity is dominant, and these two inflection points divide the dispersion curve into three parts associated with the transverse, divergent and fan waves for $k < k_1$, $k_1 < k < k_2$ and $k_2 < k < k_\sigma$, respectively. When the translating speed is equal to the newly-found critical speed

$c_{\mathrm{fan}} = 0.45$ ms^{-1}, two inflection points coalesced and become to one, and the divergent waves disappear so that transverse and fan waves joint together and are referred to as "transverse-fan waves" on the downstream. In this scenario, the third derivative of the phase function is also equal to zero resulting in the form of Pearcey integral which is worth further investigation. For a translating speed greater than c_{min} but less than c_{fan} , there is not any inflection point along the dispersion curve and transverse-fan waves are a system of smooth waves on the downstream contained in a wedge with the boundary parallel with the normal vector at $k = k_\sigma$.

This study not only provides a better understanding of ship waves, but also gives new insights into small-scaled problems like water strider locomotion at the free surface.

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Hui Liang obtained his BS, MS and PhD degrees from Department of Naval Architecture, Dalian University of Technology in 2010, 2012 and 2015, respectively. During his PhD study, his research work is concerned with the lifting theory for wing-in-ground effect and hydrofoil in proximity to a free surface and viscous vortex method under the supervision of Prof Zhi Zong. He has worked with Prof Odd Faltinsen at Department of Marine Technology, Norwegian University of Science and Technology on Harmonic Polynomial Cell (HPC) method associated with sharp corner singularity, sloshing and water entry. After achieving PhD degree, he works as a research engineer under the supervision of Dr. Xiaobo Chen at Deepwater Technology Research Centre, Bureau Veritas and is involved in the development of a novel multi-domain method for marine and offshore hydrodynamic problems. Dr. Liang's current research interests lie in mathematical aspects of hydrodynamics with emphasis on free-surface problems within the potential-flow theory in general and on wave loads and seakeeping in particular. He has authored more than 10 peer-reviewed international journal articles.

On approximations of the wave drift forces acting on semi-submersible platforms with heave plates

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The horizontal wave drift force acting on a vertical floating column, without then with a heave plate, is considered. Computations are performed with a diffraction-radiation code and through the Morison and Rainey equations. Focus is on wave frequencies around the heave resonance where the drift force may be significant, even though the scattered wave-field being weak. It is found that the Morison equation overpredicts the drift force while Rainey equations perform rather well.

Bernard Molin graduated from Ecole Polytechnique of Paris in 1974, obtained his Master of Science in Naval Architecture from University of California – Berkeley in 1975, and his Doctor of Engineering from ENSM Nantes in 1981. He was awarded the 'Habilitation à Diriger les Recherches' by Aix-Marseille University in 1996. Bernard Molin was a research engineer at Institut Francais du Petrole (IFP) from 1975 to 1994. He has been a professor at Ecole Centrale Marseille/IRPHE since 1994.

Professor Molin's research activities have been mainly concerned with nonlinear hydrodynamics (drift forces, slow drift motion, high frequency loads and response), and development of computer models for the French offshore industry. Recent involvement has included hydrodynamics of perforated structures, Vortex Induced Vibrations, slamming, moon-pool resonances, hydroelastic responses, sloshing in tanks and motion coupling, run-up effects and slow-drift excitation. Professor Molin was 22nd Georg Weinblum Memorial Lecturer (1999–2000).

Professor Molin has authored over 150 journal and conference papers. He is the author of one book '*Hydrodynamique des Structures Offshore*' published in French and in Chinese.

Some fundamental solutions in layered spherical structures

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Layered spherical structures are common. In nature, our Earth is made of layered sphere, and by human, many layered nanoparticles (spherical structures) with special properties have been successfully self-assembled/organized. While the rocks on the Earth are mostly transversely isotropic, the manmade nanoparticles are usually multi-phase coupling with material anisotropy. In this talk, I will first review and present the fundamental issues in layered spheres. I will then solve two of the problems analytically: one is the static deformation of a layered mangetoelectroelastic sphere by surface loading, and another is the Green's function solution in layered and self-gravitating Earth. It should be printed out that while the first problem has never been solved in the literature, the second (Love number) problem has been always solved numerically in Earth science community.

Keywords: Load Love number, Anisotropy, Layered Sphere, Multiferroics composites

Ernian Pan obtained his BS and MS degrees from Lanzhou University and Beijing University, respectively, and his PhD from University of Colorado at Boulder. He joined the University of Akron in 2002 and promoted to professor in 2008, with a primary appointment in the Department of Civil Engineering and a joint appointment in the Department of Applied Math. His teaching and research are in continuum/computational methods/mechanics with applications to modern engineering and Earth science problems including pavement/earth deformation due to surface and internal loadings, mechanical and electronic properties of nanoscale quantum heterostructures, and mangetoelectric effect in multiferroic composites. He has published over 270 peer-reviewed journal articles, designed a couple of software products, and coauthored a book titled *Static Green's Functions in Anisotropic Media* by Cambridge University Press.

Analysis of a fish cage platform in regular waves

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The hydrodynamic response of a fish cage surrounded by a concentric, cylindrical flotation collar in regular waves was analytically studied. To simplify the problem, the cover and the bottom of the cylinder were ignored. Small amplitude water wave theory and structural responses were assumed. In the solution procedure the fluid domain was divided into three subdomains denoted by I, II, and III. The continuity of velocity and pressure at the interface were used to set up equations in the gap regions. The Darcy's law for flow past a porous structure was applied to set up the boundary condition in the net region. The fish cage cylinder was supposed to deform like a one-dimensional beam. The transverse deflection equation of the fish cage was given based on Mandal (2013) in the structural region. By applying the eigenfunction expansion method, the problem was converted into dual series relations, and the least squares approximation was then applied to obtain the potentials in and around the cylinder. The effects of structural flexibility, drafts, sizes of the collar and porosity on the horizontal and vertical forces acting on the structure were analyzed to understand the hydrodynamic performance. The present study represented a preliminary step in the study of the fish cage.

An indirect BEM method to predict the wave-induced ship motions and loads with Haskind source Green function

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To predict the ship motions and loads with forward speed, the constant boundary element method (BEM) with Haskind source Green function is employed here. To establish the numerical model, there are three problems should be solved: One is fluid velocities of three directions on body surface in Bernoulli's equation, the second one is the m-term containing second order derivatives of velocity potentials in body surface condition, the third one is the Haskind source Green function. In present work, an indirect boundary element method is applied to solve the fluid velocities of three directions on body surface, which may be the only way to use the constant BEM; the m-term is solved by double-body flow method of Chen & Malenica (1998) which has been proved to be more accurate than Neumann-Kelvin flow method of Wu (1995); The Haskind source Green function is computed with an effective method by separating the integral domain. Then some computations are carried out to confirm the accuracy of the present method.

Lei Sun received his BS degree in Harbor, Waterway and Coastal Engineering in 2004 from School of Civil and Architecture Engineering, Dalian University of Technology, and his Ph.D in Port, Coastal and Offshore Engineering in 2009 under the supervision of Prof. Guohai Dong and Prof. Zhi Zong of Dalian University of Technology. He began to work as Lecturer and Postdoctoral in 2010 in School of Naval Architecture, Dalian University of Technology, and then became an associated professor in 2013 there. His current research includes (i) Hydrodynamics in Ship and Ocean Engineering, (ii) VIM and VIV, and (iii) Water waves and Green function.

Practical Green function for wave diffraction radiation in deep water

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The Green function, and its gradient, in the theory of diffraction radiation of time-harmonic waves by an offshore structure, or a ship at low speed, in deep water are considered. The Green function G and its gradient ∇G are expressed in the usual manner as the sum of three components that correspond to the fundamental free-space singularity, non-oscillatory local flow components L and ∇L, and waves. Simple approximations to the local flow components L and ∇L in G and ∇G are given. These approximations only involve elementary continuous functions (algebraic, exponential and logarithmic) of real arguments and are valid within the entire flow region, and are then particularly simple.

Huiyu Wu was born in 1990. He received his BS degree in Naval Architecture and Ocean Engineering in 2014 from Shanghai Jiao Tong University. He is now a PhD candidate under the supervision of Prof. Francis Noblesse in School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University. His main research interest is Green-function method in marine hydrodynamics.

Power balance for semi-infinite line arrays of wave energy converters

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We develop an approach to model macroscopically the behaviour of semi-infinite, sparse arrays of floating, axisymmetric wave energy converters in deep water. An approximate framework allows for such arrays to be characterized by frequency and direction dependent transfer functions. Two examples with converters consisting of floating single or twin-cylinders are developed in detail and investigated in physical examples. Throughout, the results are given in dimensionless form to allow for ease of application to various cases.

Dali Xu received her BSc degree in Ocean Engineering in 2008 from Harbin Engineering University and her PhD degree in Ocean Engineering in 2014 under the supervision of Prof. Shi-Jun Liao from Shanghai Jiao Tong University. In 2015, she worked as a postdoctoral researcher in wave energy harvesting in Technion—Israel Institute of Technology under the supervision of Prof. Michael Stiassnie. Since March 2016 she became a lecturer in College of Ocean Science and Engineering, Shanghai Maritime University. Her current research interests include (i) wave energy harvesting, (ii) wave-structure interaction, (iii) wind wave generation and (iv) nonlinear water waves.

Numerical study on ship-ship hydrodynamic interaction based on a high-order panel method

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A NURBS-based high-order panel method is developed for predicting the hydrodynamic interaction of two ships moving along parallel courses in shallow water. An NURBS surface is used to precisely represent the hull geometry. Velocity potential on the hull surface is described by B-spline after the strength of source is determined. Source is distributed on the hull surfaces, and the strength of source is determined by satisfying the boundary condition on the hull surfaces. The wave-making effect is neglected under the low speed assumption; the image method is used to deal with the effects of finite water depth and undisturbed free surface, a so-called infinite image Green function is applied. The time-stepping method is used to update the velocity potential and the position of each ship. Ship models of Vantorre's experiment are taken as study objects. Firstly, detailed convergence study with respect to panel size, time step and infinite image Green function is carried out. On the basis of convergence study, numerical results of two ships on meeting and overtaking conditions are compared with experimental measurements to validate the numerical method. Then, calculations are conducted for two ships during meeting and overtaking under different lateral distances between ships, different water depths and different ship speeds. Numerical results are presented to demonstrate the effects of these factors.

Keywords: Hydrodynamic interaction; shallow water; infinite image Green function; meeting; overtaking; high-order panel method

Huafu Xu received his bachelor's degree in Naval Architecture and Ocean Engineering in 2006 from Harbin Engineering University, and his master's degree in Naval Architecture and Ocean Engineering in 2009 under the supervision of Prof. Tong Ge from Shanghai Jiao Tong University. He joined the Sinopec Shengli Oilfield in July 2009 and worked there for two years. In Sept. 2011, he became a PhD candidate at Shanghai Jiao Tong University under the supervision of Prof. Zao-Jian Zou. His current research interests include numerical study of ship-ship hydrodynamic interaction in restricted waters based on high-order panel method.

Numerical and experimental study on hydrodynamic performance of a ship in finite water depth

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Vessels operating in shallow waters requires careful observation of the finite-depth effect. In present study, a Rankine source method that includes the finite-depth effect is developed in frequency domain. In order to verify present numerical methods, two experiments were carried out respectively to measure the wave loads and free motions for ship advancing with forward speed in head regular waves. Numerical results obtained by the present solution are in favorable agreement with the model tests. Further, the influence of water depths on added mass and damping coefficients, wave excitation forces, motions and unsteady wave patterns are deeply investigated. Meanwhile, the scattered wave systems in finite calm water are analyzed.

Green's function of three-dimensional vortex in the presence of free surface

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Green's Function is the singular solution to Laplace's Equation. There exist 2-D point source solutions to 2-D Laplace's equation in the presence of free surface and the same is true of 3-D. There exists 2-D point vortex solution to 2-D Laplace's equation in the presence of free surface, and the same is NOT true of 3-D. There does not exist 3-D point vortex solution to Laplace's equation, and this can be easily proved using the topological Hairy Dog Theorem as shown in this presentation. Therefore, GF of three-dimensional vortex is a line or curve rather than a point.

In the second part of the presentation, we will derive the simplest GFs of 3-D vortex in the presence of fee surface with applications to Wing-in-Ground effect and hydrofoil. Explicit expressions have been obtained of 3-D line vortex with free surface effect taken into consideration. Their behaviors are studied.

A simplified experimental setup is employed to investigate the lifting coefficient of a WIG model in a small wind tunnel to show the influence of Froude number and cruise height on the lifts. At high speed, free surface can be replaced by a rigid wall. As speed decreases, the free surface effects become more and more important.

Z. Zong obtained his PhD from Hiroshima University in 1995. He then worked in National University of Singapore as a post-doctorate research fellow (1995-1996), senior and principle research engineer (1996-2004) in IHPC, Singapore. He joined Dalian University of Technology in 2003 as a professor of hydrodynamics. His research interests include (1) hydrodynamics of high-speed vessels, among which are trimaran ship, WIG crafts, large aluminum vessels, SWATH; (2) CFD with application to marine technology; (3) nonlinear water waves.

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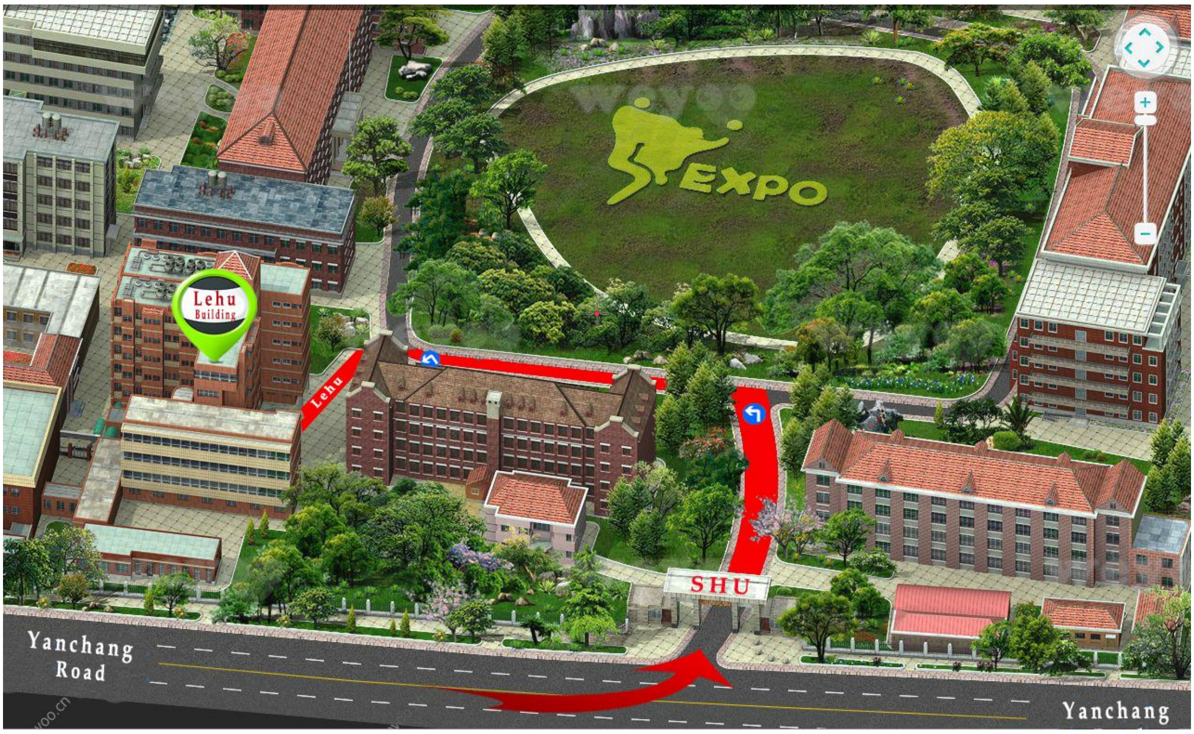
  - **地铁**：约 70 分钟。乘坐 5 号线往"莘庄"，转乘坐 1 号线（富锦路方向）到"延长路站"下车，2 号出口出站。

- **自"延长路地铁站"到"上海大学"**
  - **行走**：10 分钟到乐乎楼，15 分钟到力学所。

上海地铁

http://www.exploreshanghai.com/ditie/



From the **University Gate** (**149 Yanchang Road**) to **Lehu Hotel**

Red: From **Lehu Hotel** to the **SIAMM building (Seminar Venue)**
Blue: From **University Gate** to the **SIAMM building (Seminar Venue)**