

PHY 711 Classical Mechanics and Mathematical Methods

10-10:50 AM MWF Olin 103

22	Wed, 10/17/2012	Chap. 7, 5	Moment of inertia	
	Fri, 10/19/2012		Fall break	
23	Mon, 10/22/2012	Chap. 5	Rigid body rotation	#16
24	Wed, 10/24/2012	Chap. 5	Rigid body rotation	#17
25	Fri, 10/26/2012	Chap. 5	Rigid body rotation	#18
26	Mon, 10/29/2012	Chap. 8	Waves in elastic membranes	#19
27	Wed, 10/31/2012	Chap. 9	Introduction to hydrodynamics	
28	Fri, 11/01/2012	Chap. 9	Introduction to hydrodynamics	
29	Mon, 11/05/2012	Chap. 9	Introduction to hydrodynamics	#20
30	Wed, 11/07/2012	Chap. 9	Sound waves	
31	Fri, 11/09/2012	Chap. 9	Linear sound waves	#21
32	Mon, 11/12/2012	Chap. 9	Green's function for linear sound	
33	Wed, 11/14/2012	Chap. 9	Non-linear sound	
34	Fri, 11/16/2012	Chap. 9	Non-linear sound	Take Home Exam
35	Mon, 11/19/2012	Chap. 10	Surface waves	Take Home Exam
	Wed, 11/21/2012		Thanksgiving Holiday	
	Fri, 11/23/2012		Thanksgiving Holiday	
36	Mon, 11/26/2012	Chap. 10	Surface waves	Exam due
37	Wed, 11/28/2012	Chap. 10	Surface waves	
38	Fri, 11/30/2012	Chap. 10	Surface waves	
39	Mon, 12/03/2012		Student presentations I	
40	Fri, 12/05/2012		Student presentations II	

WAKE FOREST UNIVERSITY

Department of Physics

News

Physics Team to Lead Search for Drug Discovery

Article by Prof. Jurchescu and grad student Jeremy Ward featured on the cover of Advanced Materials

Workshop for Middle School Teachers Organized by Prof. Cho is Featured in Mashable, Huffington Post, and Fox 8 News

Article in WS Journal on Tech Expo Features Beer-Root Juice

Events

Wed. Nov. 14, 2012
Prof Chang Chan
Institute of Biophysics of the Chinese Academy of Sciences
The crossstalk between small molecules and large molecules
4:00 PM in Olin 101
Refreshments at 3:30 in Lobby

Wed Nov 29, 2012
Professor Edward Parker
University of Wisconsin, Milwaukee
4:00 PM in Olin 101
Refreshments at 3:30 in Lobby

Wed. Dec. 5, 2012
Prof. Piero Canepa
WPU

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WFU Joint Physics and Chemistry Colloquium

TITLE: The crosstalk between small molecules and macromolecules, nitric oxide as an example

SPEAKER: Professor Chang Chen

*Institute of Biophysics
Chinese Academy of Sciences
Beijing, China*

TIME: Wednesday November 14, 2012

PLACE: Room 101 Olin Physical Laboratory

Refreshments will be served at 3:30 PM in the Olin Lounge. All interested persons are cordially invited to attend.

ABSTRACT

Reactive oxygen species and reactive nitrogen species (ROS and RNS) have critical biological functions essential for normal physiology. However, overproduction or deficiency result in impaired homeostasis and is associated with pathology, such as aging, atherosclerosis, neurodegenerative diseases, obesity, and diabetes. Our research has been focused on the crosstalk between these small molecules and macromolecules, trying to explore the relationship between protein function and cellular redox status. Our major work is on how nitric oxide (NO) interacts with proteins through protein cysteine thiol modification (S-nitrosation, SNO) in cell signaling transduction and diseases.

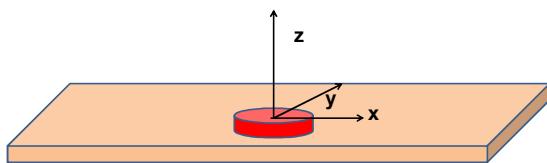
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internationally renowned for research advances;
a research emphasis on interdisciplinary studies and close interdisciplinary collaboration.*

Wave equation with source:

$$\nabla^2 \Phi - \frac{1}{c^2} \frac{\partial^2 \Phi}{\partial t^2} = -f(\mathbf{r}, t)$$

Example :

$f(\mathbf{r}, t) \Rightarrow$ time harmonic piston of radius a , amplitude $\varepsilon \hat{\mathbf{z}}$
can be represented as boundary value of $\Phi(\mathbf{r}, t)$



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Treatment of boundary values for time-harmonic force:

$$\begin{aligned}\widetilde{\Phi}(\mathbf{r}, \omega) = & \int_V \widetilde{G}(|\mathbf{r}-\mathbf{r}'|, \omega) \widetilde{f}(\mathbf{r}', \omega) d^3 r' + \\ & \oint_S \left(\widetilde{\Phi}(\mathbf{r}', \omega) \nabla' \widetilde{G}(|\mathbf{r}-\mathbf{r}'|, \omega) - \widetilde{G}(|\mathbf{r}-\mathbf{r}'|, \omega) \nabla' \widetilde{\Phi}(\mathbf{r}', \omega) \right) \cdot \hat{n} d^2 r'\end{aligned}$$

Boundary values for our example :

$$\left(\frac{\partial \tilde{\Phi}}{\partial z} \right)_{z=0} = \begin{cases} 0 & \text{for } x^2 + y^2 > a^2 \\ i\omega \epsilon a & \text{for } x^2 + y^2 < a^2 \end{cases}$$

Note: Need Green's function with vanishing gradient at $z = 0$:

$$\tilde{G}(|\mathbf{r} - \mathbf{r}'|, \omega) = \frac{e^{ik|\mathbf{r} - \mathbf{r}'|}}{4\pi|\mathbf{r} - \mathbf{r}'|} + \frac{e^{ik|\bar{\mathbf{r}} - \bar{\mathbf{r}}'|}}{4\pi|\bar{\mathbf{r}} - \bar{\mathbf{r}}'|} \quad \text{where } \bar{z}' = -z'; \quad z > 0$$

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$$\tilde{\Phi}(\mathbf{r}, \omega) = - \oint_{S: z'=0} \tilde{G}(|\mathbf{r} - \mathbf{r}'|, \omega) \frac{\partial \tilde{\Phi}(\mathbf{r}', \omega)}{\partial z'} dx' dy'$$

$$\widetilde{G}(\mathbf{r} - \mathbf{r}', \omega) = \frac{e^{ik|\mathbf{r}-\mathbf{r}'|}}{4\pi|\mathbf{r}-\mathbf{r}'|} + \frac{e^{ik|\mathbf{r}-\bar{\mathbf{r}}'|}}{4\pi|\mathbf{r}-\bar{\mathbf{r}}'|} \quad \text{where } \bar{z}' = -z'; \quad z > 0$$

$$\widetilde{G}(\mathbf{r} - \mathbf{r}', \omega)_{z=0} = \left. \frac{e^{ik|\mathbf{r}-\mathbf{r}'|}}{2\pi|\mathbf{r}-\mathbf{r}'|} \right|_{z=0}; \quad z > 0$$

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$$\begin{aligned}\widetilde{\Phi}(\mathbf{r}, \omega) &= - \oint_{S: z'=0} \widetilde{G}(|\mathbf{r} - \mathbf{r}'|, \omega) \frac{\partial \widetilde{\Phi}(\mathbf{r}', \omega)}{\partial z'} dx' dy' \\ &= -i\omega e a \int_0^a r' dr' \int_0^{2\pi} d\phi' \left. \frac{e^{ik|\mathbf{r} - \mathbf{r}'|}}{2\pi |\mathbf{r} - \mathbf{r}'|} \right|_{z'=0}\end{aligned}$$

Integration domain : $x' = r' \cos \phi'$
 $y' = r' \sin \phi'$

$$\text{For } r \gg a; \quad |\mathbf{r} - \mathbf{r}'| \approx r - \hat{\mathbf{r}} \cdot \mathbf{r}'$$

Assume $\hat{\mathbf{r}}$ is in the yz plane; $\phi = \frac{\pi}{2}$

$$\hat{\mathbf{r}} = \sin \theta \hat{\mathbf{y}} + \cos \theta \hat{\mathbf{z}}$$

$$|\mathbf{r} - \mathbf{r}'| \approx r - \hat{\mathbf{r}} \cdot \mathbf{r}' = r - r' \sin \theta \sin \phi'$$

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$$\tilde{\Phi}(\mathbf{r}, \omega) = -\frac{i\omega e a}{2\pi} \int_0^a r' dr' \int_0^{2\pi} d\phi' e^{-ikr' \sin \theta \sin \phi'}$$

$$\text{Note that : } \frac{1}{2\pi} \int_0^{2\pi} d\phi' e^{-iu \sin \phi'} = J_0(u)$$

$$\Rightarrow \tilde{\Phi}(\mathbf{r}, \omega) = -i\omega e a \frac{e^{ikr}}{r} \int_0^a r' dr' J_0(kr' \sin \theta)$$

$$\int_0^w u du J_0(u) = w J_1(w)$$

$$\Rightarrow \tilde{\Phi}(\mathbf{r}, \omega) = -i\omega \epsilon a^3 \frac{e^{ikr}}{r} \frac{J_1(ka \sin \theta)}{ka \sin \theta}$$

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Energy flux : $\mathbf{j}_e = \hat{\mathbf{v}} p$

$$\text{Taking time average: } \langle \mathbf{j}_e \rangle = \frac{1}{2} \Re(\hat{\mathbf{v}} p^*) \\ = \frac{1}{2} \rho_0 \Re((-\nabla \Phi)(-i\omega \Phi)^*)$$

Time averaged power per solid angle :

$$\left\langle \frac{dP}{d\Omega} \right\rangle = \langle \mathbf{j}_e \rangle \cdot \hat{\mathbf{r}} r^2 = \frac{1}{2} \rho_0 \epsilon^2 c^3 k^4 a^6 \left| \frac{J_1(ka \sin \theta)}{ka \sin \theta} \right|^2$$

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Effects of nonlinearities in fluid equations

-- one dimensional case

Newton - Euler equation of motion :

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla) \mathbf{v} = \mathbf{f}_{\text{applied}} - \frac{\nabla p}{\rho}$$

$$\text{Continuity equation : } \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

Assume that spatial variation confined to x direction ;

assume that $\mathbf{v} = v \hat{\mathbf{x}}$ and $\mathbf{f}_{\text{applied}} = 0$.

$$\frac{\partial v}{\partial t} + v \frac{\partial v}{\partial x} = - \frac{1}{\rho} \frac{\partial p}{\partial x}$$

$$\frac{\partial \rho}{\partial t} + v \frac{\partial \rho}{\partial x} + \rho \frac{\partial v}{\partial x} = 0$$

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$$\frac{\partial v}{\partial t} + v \frac{\partial v}{\partial x} + \frac{1}{\rho} \frac{\partial p}{\partial x} = 0$$

$$\frac{\partial \rho}{\partial t} + v \frac{\partial \rho}{\partial x} + \rho \frac{\partial v}{\partial x} = 0$$

Expressing p in terms of ρ : $p = p(\rho)$

$$\frac{\partial p}{\partial x} = \frac{\partial p}{\partial \rho} \frac{\partial \rho}{\partial x} \equiv c^2(\rho) \frac{\partial \rho}{\partial x} \quad \text{where } \frac{\partial p}{\partial \rho} \equiv c^2(\rho)$$

For adiabatic ideal gas :

$$c^2(\rho) = \frac{\gamma p}{\rho} = c_0^2 \left(\frac{\rho}{\rho_0} \right)^{\gamma-1} \quad \text{where } c_0^2 \equiv \frac{\gamma p_0}{\rho_0}$$

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$$\frac{\partial v}{\partial t} + v \frac{\partial v}{\partial x} + \frac{c^2(\rho)}{\rho} \frac{\partial \rho}{\partial x} = 0$$

$$\frac{\partial \rho}{\partial t} + v \frac{\partial \rho}{\partial x} + \rho \frac{\partial v}{\partial x} = 0$$

Expressing variation v in terms of variation of ρ :

$$\frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial t} + v \frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial x} + \frac{c^2(\rho)}{\rho} \frac{\partial \rho}{\partial x} = 0$$

$$\frac{\partial \rho}{\partial t} + v \frac{\partial \rho}{\partial x} + \rho \frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial x} = 0$$

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Traveling wave solution:

Assume : $\rho = \rho_0 + f(x - u(\rho)t)$

Need to find self-consistent equations for propagation velocity $u(\rho)$ using equations

$$\frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial t} + v \frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial x} + \frac{c^2(\rho)}{\rho} \frac{\partial \rho}{\partial x} = 0$$

$$\frac{\partial \rho}{\partial t} + v \frac{\partial \rho}{\partial x} + \rho \frac{\partial v}{\partial \rho} \frac{\partial \rho}{\partial x} = 0$$

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