Preliminary announcement of course content in

Spring 2004 **Physics 776: Advanced Gravitation Theory** B. L. Hu
Tuesdays and Thursdays 11-12:15am in Room 4208

The following was announced to students in the current 675 class in September:
I have been assigned to teach this course in Spring 2004. This offers the opportunity to have a full-year 675-776 curriculum for students interested in pursuing Ph. D. research in gravitation theory and its related or applied subjects, in particular, string theory, cosmology and gravitational wave astrophysics. All three subjects have been current `hot topics', with rapid research developments, and new faculty hires here and elsewhere. With these developments there is an increasing demand for good Ph. D. graduates with advanced training in gravitation theory. Presently 776 is the only course serving research students in gravitation and cosmology.

The course content of Physics 776 for S'04 as I have planed it so far contains two major components: **Gravitational Wave** and **New Cosmology**, plus a short introduction to differential geometry essential for gravitation theory research.

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1 Differential Geometry Cartan Calculus (moving frame approach) [~ 5 lectures] This is necessary material for almost any gravitational theory research, now opted out in 675. If most students taking this course are familiar with it we can skip it completely.
2 Gravitational Wave, from gravitational perturbation theory to the nature of gravitational waves from different sources to gravitational radiation reaction [~12 lectures]
3 New Cosmology. Theories both fundamental (e.g., standard and inflationary cosmology) and phenomenological (physical cosmology) related to recent experiments [~ 12 lectures]

The topics will be taught at the Track 2 level of MTW,
C. W. Misner. K. S. Thorne and John A. Wheeler, *Gravitation* (Freeman, San Francisco. 1973)
QC178.M57 ISBN 0 7167 0344 0 Another classic is
S. Weinberg, *Gravitation and Cosmology* (Wiley, New York, 1972)
QC6.W47 ISBN 0 471 92567 5
It's Chapter 15 alone has taught generations of cosmologists in the 70's and 80's before the dawning of the present golden age of cosmology.

We will be using reviews (e.g., Living Review of General Relativity, Classical and Quantum Gravity), proceedings (many) and journal articles for most topics, many of them in preprints can be downloaded from xxx.lanl.gov (search under gr-qc/ or astro-ph/)

The texts for the cosmology part are (suggestions welcome)

J. P. E. Peebles, *Principles of Cosmology* (Princeton University Press, 1993)
QB981.P424 ISBN 0 691 01933 9

P. Coles and F. Lucchin, *Cosmology: The origin and evolution of cosmic structures*
Second Edition (Wiley, West Sussex, UK 2002) ISBN 0 471 48909 3

For gravitational wave research a useful reference list up to 2002 can be found in
J. Centrella, Resource Letter GrW-1: Gravitational Waves Am. J. Phys. 71 (2003) 520-525
[gr-qc/0211084]

Some useful **monographs** are:
Blair, D.G., ed., *The Detection of Gravitational Waves*, (Cambridge University Press, Cambridge, U.K., 1991).

Saulson, P.R., *Fundamentals on Interferometric Gravitational Wave Detectors*, (World Scientific, Singapore, 1994).

Marck, J-A and Lasota J-A , ed., *Relativistic Gravitation and Gravitational Waves* (Cambridge University Press, 1997)

Some useful **review** articles are:
For general introduction:
Kip S. Thorne *Gravitational Radiation -- A New Window Onto the Universe* [gr-qc/9704042]

Scott A. Hughes, *Listening to the Universe with Gravitational-Wave Astronomy*
Annals Phys. 303 (2003) 142-178 [astro-ph/0210481]

On gravitational radiation reaction:
Eric Poisson, *The motion of point particles in curved spacetime*
111 pages, 10 figures [gr-qc/0306052] We will spend some time on this topic, as it has broader theoretical interest beyond gravitational wave physics.

Our discussion will be more focused on the theoretical properties and some detection aspects of gravitational waves; less on sources, which bears more on astrophysics (Prof. Cole Miller of the astronomy department is an expert on these aspects). Good summaries can be found in, e.g.,

Curt Cutler, Kip S. Thorne, *An Overview of Gravitational-Wave Sources*
in Proceedings of GR16 (Durban, South Africa, 2001) [gr-qc/0204090]

Kip S. Thorne, *Probing Black Holes and Relativistic Stars with Gravitational Waves* in *Black Holes and Relativistic Stars*, Proceedings of a Conference in Memory of S. Chandrasekhar, Ed. R. M. Wald (University of Chicago Press, 1998, Chicago) pp 41-78 . [gr-qc/9706079]

Students taking the course are required to do a **research project** chosen from either one of the two areas aided by my supervision, and give a **final presentation** with a **short scholarly paper**.

Note that **776 is designed such that students can take it more than once** to benefit from the changing current topics and/or the association with a different instructor. So students who have taken this course before can also register (maybe through a different format – consult Dr. Chant)

If you have any questions or suggestions please write to me hub@physics.umd.edu or call 5-6029