AST 860, Gravitational Astrophysics Syllabus 26 April 2006

Class	Tu 4:10–5:30, Th 8:40–10:00, 1308 BMPS Bldg.
Instructor	Mr. Ed Loh, 1219 BMPS, 355–9200 x2480, Loh@msu.edu
Web	http://www.pa.msu.edu/courses/2006spring/AST860/
Grading	Homework, 20%; midterm exam, 30%; final exam, 50%
Textbook	*Relativity, Gravitation, & Cosmology*, Ta-Pei Cheng, Oxford, 2005.

^{hwk}	*Date*	*Topic*	*Reading*
10	12 Jan	Introduction, lessons of special theory that apply to gravity, Minkowski metric, Schwarzschild metric	§1–2
17		Bending of light, time dilation, Shapiro effect	§3.3, 6.1–6.2
	19	Perihelion shift of Mercury	
^{1}24		Robertson-Walker metric, Hubble's Law, redshift	§7
	26	Angle & flux in an expansing universe	
^{2}31		Friedmann's equation	§8
	2 Feb	Observations: comoving coordinate *vs.* redshift	
^{3}7		Equivalence principle: "happiest thought in my life"—Einstein. Equation of motion with gravity.	§3
	9	Equation of motion in curved space	
^{4}14		Experimental foundation of the theory of gravity; Eötvös' & Dicke's experiments	§3.2.1
	16	Path to Einstein's equation; stress-energy tensor	§10.4
^{5}21		Transformation of tensors; derivative of a tensor	§11.1
	23	Parallel transport of a vector; Riemann-Christoffel curvature tensor	§11.2, 11.3
^{6}28		Review: What are the main ideas of each class?	
	2 Mar	Midterm exam	
7	9	Spring break	
14	Mar	Einstein's field equation, Bianchi identity, conservation of energy & momentum	§12
	16	Schwarzschild metric	§12.3
^{7}21	23	Einstein's discovery of the field equation: 1907, Einstein's happiest thought; 1913, Einstein & Grossmann on tensors; 1915, energy & momentum conservation, general covariance.	Pais
^{8}28		Friedmann's equation	§12.4
	30	Cosmological constant	§9, Peebles&Ratra
^{9}4	6 Apr	Inflation	
^{10}11		Casimir effect	Bordag&M&M
		Recombination	PPC pp. 165–175
	13	WMAP	WMAP
^{11}18			

hwk	Date	Topic	Reading
20		Gravitational radiation, Hulse-Taylor pulsar	§13,T,TW
25			
27		Review of key ideas	
2	May	Final exam, Tues., 5:45–7:45.	

Reference books

- *Principles of Physical Cosmology*, P. James Peebles, Princeton University, 1993.
- *Spacetime Physics: Introduction to Special Relativity*, Edwin Taylor & John Wheeler, Freeman, 1992.
- *Gravitation & Cosmology: Principles & Applications of the General Theory of Relativity*, Steven Weinberg, Wiley, 1972.
- *Gravitation*, Charles Misner, Kip Thorne, & John Wheeler, Freeman, 1973.
- *Gravitation & Spacetime*, 2nd ed., H. Ohanian & R. Ruffini, Norton, 1994.

Readings (Most have links.)

- Bordag, M., Mohideen, U., & Mostepanenko, V., 2001, New developments in the Casimir effect, Phys. Rept. **353**, 1.
- Hubble, E., 1929, Relation between distance and radial velocity among extra-galactic nebulae, Proc. Nat. Acad. Sci. **15**, 168.
- Pais, A., 1982, *Subtle is the Lord*, (Oxford University, New York), §9–12, §14.
- Pound, R., & Rebka, G., 1960, Apparent weight of photons, Phys. Rev. Lett. **4**, 337.
- Peebles, P., & Ratra, B., 2003, Cosmological constant and dark energy, Rev. Mod. Phys. **75**, 559.
- Shapiro, I., et al., 1968, Fourth test of general relativity: preliminary results, Phys. Rev. Lett. **20**, 1265.
- Taylor, J., 1994, Binary pulsars and relativistic gravity, Rev. Mod. Phys. **66**, 711.
- Taylor, J., & Weisberg, J., 1989, Further experimental tests of relativistic gravity using the binary pulsar 1913+16, ApJ **345**, 434.
- Vessot, R., et al., 1980, Test of relativistic gravitation with a space-borne hydrogen maser, Phys. Rev. Lett. **45**, 2081.