Papers for the Mini-symposium of *The Physics of Galaxy Clusters*

Students who wish to obtain credit points can choose one research paper from a selection of "classical papers" that they have to read and present at a mini-symposium. The symposium will be held on July 24, 2012, 9:15am at the seminar room at ARI (Mnchhofstrasse 12-14). Given the prospective number of 13 participants, it is expected to last about 3.5 hours (including a coffee break). The other students are expected to actively participate with questions. Active participation through clever questions may own the students bonus points.

The talks are free in format (chalk board or power point/pdf) and should be about 10 minutes in length, followed by 5 minutes of discussion. Since not all papers are at an equal level of complexity, the following discussion will adjust accordingly. As a rule of thumb, we expect the student with a simpler paper to think slightly beyond its borders.

In addition to the talk, the students are expected to deliver a **little article (2-4 pages)** that should cover the presentation and is due at the *beginning of the mini-symposium*. It may also contain a (somewhat lengthier) derivation of a result that the student may wish to skip during the talk in the interest of time. The talk/article may be constructed around the following guiding concepts:

- motivation: why is this topic important? how does it connect to the lecture?
- clearly state the problem and the main aspects of its derivation/solution
- stress the main ideas using drawings or simple physical concepts rather than lengthy math
- use your own words, simplify the derivation if possible – do not copy the paper!
- summarize the main achievements of the paper
- critically assess potential weaknesses or point out to future directions (bonus)

→ You are only expected to read the indicated papers and the lecture script; of course you can read more, but you don't have to. Papers in brackets are supporting material that may be helpful.

Grading. There will a maximum of 10 points for the talk (including questions during the discussion session) and for the article, respectively.

Paper assignment. Until Thursday, July 5, 2012 at 6pm, you may want to send me by email your top three choices (`christoph.pfrommer@h-its.org`). Each choice should be drawn from the three topics separated by horizontal lines, respectively, i.e., from Sections 1+2, Section 3, and Section 4 (order according to your preferences). I will assign the papers by Sunday July 8, 2012. I try to accommodate your choices and aim for an equal balance among the three topics. Hence, there may be cases where none of your choice is any more available for which I apologize in advance. In the exceptional case, if there is a serious conflict with the assigned paper, you can see me after the next lecture (July 10, 2012) so that we can resolve such a potential conflict. You may want to obtain those papers through your university student account from ADS:
`http://adsabs.harvard.edu/abstract_service.html`

Good luck!
Dr. Christoph Pfrommer & Prof. Dr. Volker Springel

1. Overview and background:
T1: The cosmic triangle, Bahcall et al. (1999)

2. Evolution of the dark component
2.1 Growth of perturbations
T2: Gravitational instability - Zel'dovich approximation, Zel'dovich (1970)

2.2 Statistics and non-linear evolution (incl. power spectra)
T3: Clustering bias, Kaiser (1984)
T4: Spatial clustering of dark matter haloes, Mo & White (1996)

2.3 Spherical collapse (incl. Press-Schechter mass function)
T5: Clusters as cosmological probes, Bahcall et al. (1997, 1998)
T6: Imprints of primordial non-Gaussianities on cluster abundance, Dalal et al. (2008)

2.4 Structure of clusters
T7: Structure of cold dark matter halos, Navarro, Frenk & White (1996) + Visbal et al. (2012) f or a recent attempt of an explanation
T8: Concentration-mass relation, Bullock et al. (2001) + Prada et al. (2011) and Ludlow et al. (2012) for recent developments on cluster scales
T9: Dark matter substructures and survival times, Ghigna et al. (1998)

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3. Evolution of the baryonic component
3.1 Non-radiative physics
T10: The baryon content of galaxy clusters, White et al. (1993)
T11: Accretion onto clusters + "ram-pressure stripping", Gunn & Gott (1972)

3.2 Radiative physics
3.2.1 Radiative cooling
T12: Modified Entropy Models for the ICM, Voit et al. (2002)

3.2.2 Energy feedback
T13: AGN feedback, Churazov et al. (2001)
T14: AGN feedback - impact on cD galaxies, Croton et al. (2006)

3.2.3. Transport processes of gas and thermal stability
T15: Thermal conduction at cold fronts (without magnetic fields),
Xiang et al. (2007) [+ Markevitch et al. (2007)]
T16: Magnetic draping at cold fronts, Lyutikov (2006) [+ Dursi et al. (2008)]
T17: Magneto-thermal instability, Balbus (2001)
T18: Heat flux-driven buoyancy instability, Quataert (2008)

3.3 Non-thermal processes
T19: Particle acceleration at astrophysical shocks, Blandford & Eichler (1987): focus on Sect. 4.3 (and Sects. 1, 2 for background reading)

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4. Cluster physics informed by different observables:
4.1 Optical: galaxies and lensing
T20: Mapping the dark matter with gravitational lensing, Kaiser & Squires (1993)
T21: Galaxy harassment, Moore et al. (1996)

4.2 X-rays: gastrophysics at high-resolution
T22: The bullet cluster: a dark matter laboratory, Clowe et al. (2006) + Markevitch et al. (2002)
T23: Turbulence in the ICM - pressure fluctuations, Schuecker et al. (2004)
T24: Turbulence in the ICM - line width broadening, Sunyaev et al. (2003)

4.3 Sunyaev-Zel'dovich (SZ) effect: cluster calorimeter
T25: SZ-discovery paper, Sunyaev & Zel'dovich (1972)

4.4 Diffuse cluster radio emission
T26: Nonthermal Emission and Acceleration of Electrons, Petrosian (2001)
T27: Radio relics, Ensslin et al. (1998)
T28: Radio halos and CR transport, Ensslin et al. (2011)

Paper details (alphabetically ordered, according to first author):

- The Most Massive Distant Clusters: Determining Ω and σ_8; Bahcall, Neta A.; Fan, Xiaohui; Astrophysical Journal v.504, p.1 (1998)
- Constraining Omega with Cluster Evolution; Bahcall, Neta A.; Fan, Xiaohui; Cen, Renyue; Astrophysical Journal Letters v.485, p.L53 (1997)
- The Cosmic Triangle: Revealing the State of the Universe; Bahcall, N. A.; Ostriker, J. P.; Perlmutter, S.; Steinhardt, P. J.; Science, Vol. 284, Iss. 5419, p. 1481 (1999)
- Convective and Rotational Stability of a Dilute Plasma; Balbus, Steven A.; The Astrophysical Journal, Volume 562, Issue 2, pp. 909-917. (2001)
- Particle acceleration at astrophysical shocks: A theory of cosmic ray origin; Blandford, Roger; Eichler, David; Physics Reports, Volume 154, Issue 1, p. 1-75. (1987)
- Evolution of Buoyant Bubbles in M87; Churazov, E.; Brggen, M.; Kaiser, C. R.; Bhringer, H.; Forman, W.; The Astrophysical Journal, Volume 554, Issue 1, pp. 261-273. (2001)
- A Direct Empirical Proof of the Existence of Dark Matter; Clowe, Douglas; Bradac, Marusa; Gonzalez, Anthony H.; Markevitch, Maxim; Randall, Scott W.; Jones, Christine; Zaritsky, Dennis; The Astrophysical Journal, Volume 648, Issue 2, pp. L109-L113. (2006)
- The many lives of active galactic nuclei: cooling flows, black holes and the luminosities and colours of galaxies; Croton, Darren J.; Springel, Volker; White, Simon D. M.; De Lucia, G.; Frenk, C. S.; Gao, L.; Jenkins, A.; Kauffmann, G.; Navarro, J. F.; Yoshida, N.; Monthly Notices of the Royal Astronomical Society, Volume 365, Issue 1, pp. 11-28. (2006)
- Imprints of primordial non-Gaussianities on large-scale structure: Scale-dependent bias and abundance of virialized objects; Dalal, Neal; Dor, Olivier; Huterer, Dragan; Shirokov, Alexander; Physical Review D, vol. 77, Issue 12, id. 123514 (2008)
- Draping of Cluster Magnetic Fields over Bullets and Bubbles-Morphology and Dynamic Effects; Dursi, L. J.; Pfrommer, C.; The Astrophysical Journal, Volume 677, Issue 2, pp. 993-1018. (2008)

- Cosmic ray transport in galaxy clusters: implications for radio halos, gamma-ray signatures, and cool core heating; Enlin, T.; Pfrommer, C.; Miniati, F.; Subramanian, K.; Astronomy & Astrophysics, Volume 527, id.A99 (2011)
- Cluster radio relics as a tracer of shock waves of the large-scale structure formation; Ensslin, Torsten A.; Biermann, Peter L.; Klein, Ulrich; Kohle, Sven; Astronomy and Astrophysics, v.332, p.395-409 (1998)
- A Fundamental Relation between Supermassive Black Holes and Their Host Galaxies; Ferrarese, Laura; Merritt, David; The Astrophysical Journal, Volume 539, Issue 1, pp. L9-L12. (2000)
- Dark matter haloes within clusters; Ghigna, Sebastiano; Moore, Ben; Governato, Fabio; Lake, George; Quinn, Thomas; Stadel, Joachim; Monthly Notices of the Royal Astronomical Society, Volume 300, Issue 1, pp. 146-162. (1998)
- On the Infall of Matter Into Clusters of Galaxies and Some Effects on Their Evolution; Gunn, James E.; Gott, J. Richard, III; Astrophysical Journal, vol. 176, p.1 (1972)
- On the spatial correlations of Abell clusters; Kaiser, N.; Astrophysical Journal, Part 2 - Letters to the Editor, vol. 284, p. L9-L12. (1984)
- Mapping the dark matter with weak gravitational lensing; Kaiser, Nick; Squires, Gordon; Astrophysical Journal, Part 1, vol. 404, no. 2, p. 441-450. (1993)
- The Dynamical State and Mass-Concentration Relation of Galaxy Clusters; Ludlow, Aaron D.; Navarro, Julio F.; Li, Ming; Angulo, Raul E.; Boylan-Kolchin, Michael; Bett, Philip E.; http://arxiv.org/abs/1206.1049
- Magnetic draping of merging cores and radio bubbles in clusters of galaxies; Lyutikov, M.; Monthly Notices of the Royal Astronomical Society, Volume 373, Issue 1, pp. 73-78. (2006)
- A Textbook Example of a Bow Shock in the Merging Galaxy Cluster 1E 0657-56; Markevitch, M.; Gonzalez, A. H.; David, L.; Vikhlinin, A.; Murray, S.; Forman, W.; Jones, C.; Tucker, W.; The Astrophysical Journal, Volume 567, Issue 1, pp. L27-L31. (2002)
- Shocks and cold fronts in galaxy clusters; Markevitch, Maxim; Vikhlinin, Alexey; Physics Reports, Volume 443, Issue 1, p. 1-53. (2007)
- An analytic model for the spatial clustering of dark matter haloes; Mo, Hojun. J.; White, Simon. D. M.; Monthly Notices of the Royal Astronomical Society, Volume 282, Issue 2, pp. 347-361. (1996)
- Galaxy harassment and the evolution of clusters of galaxies; Moore, Ben; Katz, Neal; Lake, George; Dressler, Alan; Oemler, Augustus; Nature, Volume 379, Issue 6566, pp. 613-616 (1996). (1996)
- The Structure of Cold Dark Matter Halos; Navarro, Julio F.; Frenk, Carlos S.; White, Simon D. M.; Astrophysical Journal v.462, p.563 (1996)
- Buoyancy Instabilities in Weakly Magnetized Low-Collisionality Plasmas; Quataert, Eliot; The Astrophysical Journal, Volume 673, Issue 2, pp. 758-762. (2008)
- Probing turbulence in the Coma galaxy cluster; Schuecker, P.; Finoguenov, A.; Miniati, F.; Bhringer, H.; Briel, U. G.; Astronomy and Astrophysics, v.426, p.387-397 (2004)
- The Observations of Relic Radiation as a Test of the Nature of X-Ray Radiation from the Clusters of Galaxies; Sunyaev, R. A.; Zeldovich, Ya. B.; Comments on Astrophysics and Space Physics, Vol. 4, p.173 (1972)

- On the Detectability of Turbulence and Bulk Flows in X-ray Clusters; Sunyaev, R. A.; Norman, M. L.; Bryan, G. L.; Astronomy Letters, vol. 29, p. 783-790 (2003)
- On the Nonthermal Emission and Acceleration of Electrons in Coma and Other Clusters of Galaxies; Petrosian, Vah; The Astrophysical Journal, Volume 557, Issue 2, pp. 560-572. (2001)
- Halo concentrations in the standard cold dark matter cosmology; Prada, Francisco; Klypin, Anatoly A.; Cuesta, Antonio J.; Betancort-Rijo, Juan E.; Primack, Joel; Monthly Notices of the Royal Astronomical Society, Online Early (2012); http://arxiv.org/abs/1104.5130
- A Simple Model for the Density Profiles of Isolated Dark Matter Halos; Eli Visbal, Abraham Loeb, Lars Hernquist; http://arxiv.org/abs/1206.5852
- Modified Entropy Models for the Intracluster Medium; Voit, G. Mark; Bryan, Greg L.; Balogh, Michael L.; Bower, Richard G.; The Astrophysical Journal, Volume 576, Issue 2, pp. 601-624. (2002)
- The baryon content of galaxy clusters: a challenge to cosmological orthodoxy; White, Simon D. M.; Navarro, Julio F.; Evrard, August E.; Frenk, Carlos S.; Nature, Volume 366, Issue 6454, pp. 429-433 (1993)
- Gravitational instability: An approximate theory for large density perturbations. Zel'dovich, Ya. B.; Astronomy and Astrophysics, Vol. 5, p. 84 - 89 (1970)