

**Second Circular – Workshop of the International Space Science Institute (ISSI)**

## **Clusters of Galaxies: Physics and Cosmology**

**20 - 24 November 2017**

### **Conveners**

Andrei Bykov (Ioffe RU & ISSI, CH)  
Marcus Brüggen (Hamburger Sternwarte, DE)  
Jelle Kaastra (SRON, Utrecht, NL)  
Maxim Markevitch (NASA GSFC, USA)  
Maurizio Falanga (ISSI, Bern, Switzerland)  
Frits Paerels (Columbia University, USA)  
Rudolf von Steiger (ISSI, Bern, Switzerland)

**Local organisation:** Alexandra Lehmann, ISSI, [Lehmann@issibern.ch](mailto:Lehmann@issibern.ch)  
Phone: +41 31 631 48 96, Fax: +41 31 631 48 97

### **The Workshop web site :**

<http://www.issibern.ch/workshops/Gclusters/>

### **The Context of the Workshop**

The International Space Science Institute (ISSI) is holding a series of three Workshops on physics of astrophysical objects with extreme energy release ranged from black holes of stellar mass to clusters of galaxies. The workshops series follow the ISSI Workshops hold in 2010-2015 which covered our contemporary knowledge about astrophysical magnetic fields of different scales, turbulence and particle acceleration processes in cosmic plasmas. The present Workshop intends to a wide and deep discussion of physics and cosmology of clusters of galaxies - the largest gravitationally bound objects with extreme energy release. The Workshop will review the observations and theory of clusters of galaxies with the aim to understand the physics of dark matter and gas structures in clusters of galaxies, their multi-wavelength observational appearance and modeling. Attention will be given to the cosmological aspects of clusters of galaxies.

### **Objectives of the Workshop**

The ISSI Workshop is devoted to an in-depth examination of complex astrophysical events with extreme energy release via multi-wavelength observations and modeling. Clusters of galaxies are the largest gravitationally bound structures in the Universe. Galaxy clusters now are one of the most important cosmological probes to test the standard cosmological models. Constrains on the Dark Energy equation of state from the cluster number density measurements, deviations from the Gaussian perturbation

models, Sunyaev-Zeldovich effect as well as the dark matter profiles are among of the issues to be studied with clusters.

The baryonic composition of clusters is dominated by hot gas that is in quasi-hydrostatic equilibrium within the dark matter dominated gravitational potential well of the cluster. The hot gas is visible through spatially extended thermal X-ray emission, and it has been studied extensively both for assessing its physical properties and also as a tracer of the large scale structure of the Universe.

Magnetic fields as well as a number of non-thermal plasma processes play a role in clusters of galaxies as we observe from the radio observations by VLA, GMRT and LOFAR. A goal of the proposed workshop is to review those processes and to investigate how they are linked together. We will make use of the latest theoretical and observational developments in the field.

One of the aspects is the Sunyaev-Zeldovich effect in clusters. While frequently this effect is used for cosmological purposes, the signal can be used to get deeper insight into the distribution and properties of the hot gas in clusters, and we intend to discuss the implications of the findings of ESA's Planck mission with respect to the cluster gas physics.

The amount of data on clusters of galaxies obtained with the XMM-Newton and Chandra satellites is still growing, and the missions have produced large, high quality samples of clusters. We will discuss also the findings obtained from the finest spectral imaging obtained by these satellites. The Suzaku X-ray satellite has provided a low-background view of the cluster outskirts. The Hitomi instrument has obtained the first X-ray spectrum of a galaxy cluster with an energy resolution sufficient to detect turbulence

Clusters of galaxies are not isolated entities in the Universe: they are connected through a filamentary cosmic web. Theoretical predictions indicate the way this web is evolving. In the early Universe most of the gas in the web was relatively cool (about 10,000 K). In the present Universe, however, about half of all the baryons are predicted to be in a warm phase (10<sup>(5)</sup>-10<sup>(7)</sup> K), the Warm-Hot Intergalactic Medium (WHIM), with temperatures intermediate between the hot clusters and the cool absorbing gas causing the Lyman-alpha forest. In cluster outskirts the connection to these structures can be studied. ESA's Planck instrument found an extended bridge of hot gas connecting two clusters of galaxies Abell 399 and Abell 401, shedding light on the 'missing baryons' in the cluster vicinity.

These and other aspects of the observations and physics of clusters of galaxies will be discussed in the workshop and presented in the ISSI Springer book.

**The Workshop will cover the following main themes:**

The main goal of the proposed ISSI Workshop is to discuss the state of the art of the research and future prospective of studies of supernovae. Following discussions by the Conveners, it is proposed that the Workshop will cover the following main themes:

- **Cosmology with clusters of galaxies**
- **Observations, theory and numerical simulations of:  
cluster mergers,  
central AGN / ICM interactions,  
cluster abundances, cluster turbulence,  
magnetic fields and non-thermal particles in clusters,  
plasma processes in clusters**
  
- **Interface between clusters and the cosmic web**

Presentations by those attending will be structured around the above headings. This list, subject to discussion and assessment at the Workshop, should become the set of chapter headings for the ISSI book. All of those attending will be expected to contribute to one or more of the chapters.

### **Product**

Following the Workshop, its output will be published as a volume in the Space Science Series of ISSI by Springer, in parallel with the publication of the papers in Space Science Reviews. It is expected that a total of about 9 sections and between 10 and 15 review style and quality papers, submitted to the usual refereeing process will be published in the book. Papers will be based on talks presented at the Workshop and will reflect the discussions that will be held among the participants during the Workshop.

### **Location**

The Workshop will be held at the International Space Science Institute, Hallerstrasse 6, 3012 Bern, Switzerland.

### **Attendance**

This will be by invitation only with ~ 42 participants maximum including young scientists. The draft version of the Workshop program is attached to this 2nd circular.

### **Young scientists**

Under its special program for supporting young scientists, ISSI invited four early career scientists, within two years of their PhD, to take full part in the Workshop.

### **Funding**

ISSI will provide the subsistence costs (hotel and a per diem to cover meals) to all participants but not the travel costs. This refers only to the participants; in case they bring their partners or families, they will need to pay for the additional cost of the accommodation. There will be no registration fee for the Workshop.

## **Travelling to Bern**

Bern can be reached easily from two international airports: [Zurich \(ZRH\)](#) and [Geneva \(GVA\)](#). Direct intercity trains to Bern depart every half hour from inside the airport buildings; see [www.rail.ch](http://www.rail.ch) for detailed departure times. The travel time is ~1.5 hours from Zurich airport and ~2 hours from Geneva airport.

There is also a local airport (Bern, BRN <http://www.flughafenbern.ch/>), located a 20 minute shuttle ride from the city centre, with direct connections to Munich, Berlin Schönefeld, Hamburg, Amsterdam, London City, Vienna and Paris Orly.

Bern is connected to many European cities by fast intercity trains (e.g. TGV Paris-Bern in 4.5 hours, or Frankfurt-Bern 5 hours). Timetable information of trains within and around Switzerland can be found at [www.rail.ch](http://www.rail.ch). Also check out our website [www.issibern.ch/](http://www.issibern.ch/) for a few more travel tips such as links to city maps of Bern, weather forecasts, tourist information etc...

## **Hotel reservations**

A block booking has been made in city centre hotels for the Workshop. All participants at the workshop are requested to contact the workshop secretary, Alexandra Lehmann (Tel. +41-31-631-4896, Fax: +41-31-631-4897, email: [Lehmann @issibern.ch](mailto:Lehmann@issibern.ch)), to indicate their arrival and departure dates and times, as well as any special requests they may have (e.g. double room). Please note that all hotel reservations have to be made by the ISSI Secretariat. The invitation letters for visas etc can be obtained from the ISSI Secretariat.

A confirmation will be returned within a few days. Block bookings have been made in nearby hotels; please see <http://www.issibern.ch/localguide/location.html> for maps that indicate the location of ISSI and of the hotels (go to “hotels”, and near the bottom of the page “map of hotels”).

## **Schedule**

Invitations and the Second Circular:	30 May 2017
Registration deadline:	10 September 2017
Final program:	20 October 2017
Hotel deadline:	20 October 2017
Workshop:	20–24 November 2017