Event Information	
Title	**Cosmic Rays: the salt of the star-formation recipe.**
Place	Dipartimento di Fisica e Astronomia-University of Florence, Arcetri, Florence (Italy)
Organiser´s Institute	Istituto Nazionale di Astrofisica - Osservatorio Astrofisico di Arcetri (INAF-OAA) Marco Padovani - padovani@arcetri.astro.it Víctor M. Rivilla - rivilla@arcetri.astro.it
Date	June 19-22 2018
No. of participants	~60-80
Total event cost	8 kEUR
Other sources of funding	“Premiale INAF iALMA” grant (P.I. L. Testi)

REQUEST

Requested contribution	The Radionet support will cover about 60% of the costs of the workshop. We ask for a total amount of **5 kEUR** to be funded by Radionet.
Use of the RadioNet contribution	Expenses covered by the RadioNet support will be used: i) to **waive the registration fee** for most of the participants (first of all PhD students and postdocs); (ii) for 2-3 meals + 6-8 coffee breaks + “Aperitivo” offered at Galileo’s house; and (iii) for the material for the participants (book of abstracts, badges, workshop’s notebook). The venue will be cost-free. As members of the Astrophysical Observatory of Arcetri, we are allowed to use the Physics and Astronomy Department of the University of Florence. This place is well suited for a workshop event of 60-80 participants, and has already successfully hosted many workshops in the last years (e.g. *“Fractionation of isotopes in space: from the solar system to galaxies”* https://www.arcetri.astro.it/~fraction/index.html, organized by us; 10-13 October 2016), including also Radionet-funded events (http://www.radionet-eu.org/radionet3-workshop-multi-frequency-mm-wave-radio-telescopes-other-software-controlled-operations, 5-7 October 2015).
How the event fits in the RadioNet framework	**Cosmic rays (CRs)** are a key ingredient in many fields of Astrophysics and in particular in **Star Formation**, but despite their great relevance our understanding is still relatively incomplete. Thanks to the data delivered by the new generation of radio and (sub)millimeter telescopes (**Radionet facilities** as NOEMA, IRAM 30m, APEX, Effelsberg, LOFAR, VLBI; and other such as ALMA and VLA), we have now the opportunity of attaining a comprehensive knowledge about the role of CRs in the physics and chemistry of the interstellar medium, hence about the processes leading to star and planet formation. Observations are needed to constrain the multiple aspects of the proposed theoretical models, and models are required to properly interpret observations. Given the multidisciplinarity of the topics where CRs play an important role, we propose a workshop to **bring together for the first time the observational and theoretical communities** working on CRs in star-forming environments to present their recent results, and to trigger active discussions which will establish a solid basis about the key challenges in CR-related physics and chemistry for the next decade. In order to feed the discussion, the workshop will offer several sessions focused on the most relevant field of star formation where CRs play a crucial role, which are briefly presented in the following: - CRs are the primary source of ionisation in dense molecular clouds shielded by the interstellar UV radiation field, and then **produce molecular ions and electrons that activate a rich chemistry** in the dense cold gas, leading to the **formation of molecules** of increasing complexity, up to pre-biotic and possibly biotic molecules; - The ionisation fraction controls the gas-magnetic field coupling, driving the dissipation of turbulence and angular momentum transfer, thus playing a **crucial role in the protostellar collapse and accretion discs**; - CRs are also a **source of heating** for molecular clouds because of the energy of secondary electrons produced by the ionisation process and by the products of the exothermic reactions; - In the inner parts of a cloud, CRs control the distribution of charge on dust grains and therefore the rate at which grains coagulate to form larger conglomerates, a fundamental mechanism for the **formation of planetesimals**;

	- CRs also induce stochastic heating on dust grains, allowing surface radicals to move faster at lower temperature, increasing the **formation of complex organic molecules** (COMs) and desorbing them from dust grains directly or via secondary UV photons. - Finally, recent theories on **local acceleration of CRs inside protostars** can explain the **synchrotron emission** and the **extremely high CR ionisation rate (ζ)** observed in protostellar jet shocks as well as the **overabundance of ^{10}Be** in meteorites due to spallation reactions. The **CR ionisation rate**, defined as the number of ionisation of H_2 molecules per unit time, is the key-brick parameter which governs many processes of the physics and chemistry of star-forming regions. It is one of the main parameters used in **chemical codes** to interpret the observed abundances of molecules, and in non-ideal **magnetohydrodynamic (MHD) simulations** it determines the microscopic resistivities (ambipolar diffusion, Hall, Ohm) affecting the timescale of the collapse of a molecular cloud core and the formation of a protostellar disc. The value of ζ strongly depends on the environment, decreasing from diffuse clouds to dense cores, to protostellar discs. This fundamental parameter can be derived observationally using different methods which rely (all of them) on the detection of **molecular ions** through rotational spectroscopy in the radio and (sub)mm wavelength ranges, using radiotelescopes such as IRAM-30m, NOEMA, ALMA, APEX and Effelsberg. Moreover, CRs electrons can be also responsible for the **synchrotron emission** in protostellar jets and protostars. This non-thermal emission is detected with increasing accuracy with the last-generation radiotelescopes such as LOFAR, VLA, and GMRT. This phenomena are still poorly understood, but are very relevant for the irradiation of protoplanetary discs and thus in planet formation. Despite the relevance of CRs in many fields of astrophysics, the interplay between observers, chemical modellers, and theoreticians is still missing. Therefore, **the proposed workshop has the goal of bringing together experts in theory and simulations of CR propagation, astrochemists, and observers** to share ideas, discuss about recent and present results, and identify the key challenges regarding the chemistry and the physics of CRs for the near future. The workshop will be organised in 4 different sessions (+ a Final General discussion) during 4 days: - *June 19 (afternoon):* Welcome and **Session I - Role of CRs in star formation** (how CRs shape the physical and thermodynamical structure of astronomical sources); - *June 20:* **Session II - Methods to derive the CR ionisation rate from observations in different environments** (prestellar cores, protostars, hot cores/corinos, protoplanetary discs); - *June 21:* **Session III - The impact of CRs on the formation of COMs and the possible origin of Life** (implementation in theoretical astrochemical models and laboratory experiments of CR effects); - *June 22 (morning):* **Session IV - CRs factories: local acceleration in protostars (**jet and disc dynamics, irradiation of protoplanetary discs) and **Final Discussion Session**. Each session will start with 1-2 invited talks given by world-class experts in each of the fields, followed by several contributed talks from the participants. A couple of poster sessions will be also scheduled during the workshop. The final Discussion Session scheduled during the last day will be centred on what are the missing pieces of the current puzzle and mainly **to identify the observations that can answer the issues raised by models**. **PhD students and Postdoctoral Fellows** will be encouraged to attend the workshop and give contributed talks or present posters. They will have the opportunity to interact with international experts in different fields (star formation, astrochemistry, particle physics). The interdisciplinary environment will be particularly beneficial for students and young postdocs, who might find new directions in their research by linking the different fields that coexist in the workshop. Furthermore, we as organisers will favour **gender quality** and we will assure that at least a 50% of the members of the SOC and invited speakers will be women.
Relevance of the event for RadioNet	The discussion arising from this workshop will settle the ground for a more efficient exploitation of the current facilities, **especially those coordinated by RadioNet**. We stress that we expect not only participants who already work on CRs, but also experts on different aspects of star formation with the aim of make everyone aware about the relevance of CRs in their respective research. This will result in new proposals to exploit RadioNet telescopes. Besides, all these works will contribute to design the next challenges in the field and to prepare future ambitious projects making use of powerful facilities available in the following years: **SKA, ALMA (bands 1-2), and the next generation VLA**. As a result of this workshop, the need of new instrumental capabilities to answer specific scientific questions surely arise. As an example, the detection of the DCO+(1-0) line at 72 GHz would be extremely useful to derive accurately the CR ionisation rate in prestellar sources. However, this frequency is not observable with current facilities (it would require an extension of the frequency coverage of the new 4mm receivers installed in the IRAM-30m telescope, for instance). Then, the workshop may provide new ideas to **push for the design and implementation of new instrumentation** of current RadioNet facilities.
Ethics	The workshop will be a harassment-free experience for all participants, regardless of gender, sexual orientation, disability, physical appearance, race, age, political opinion or religion.