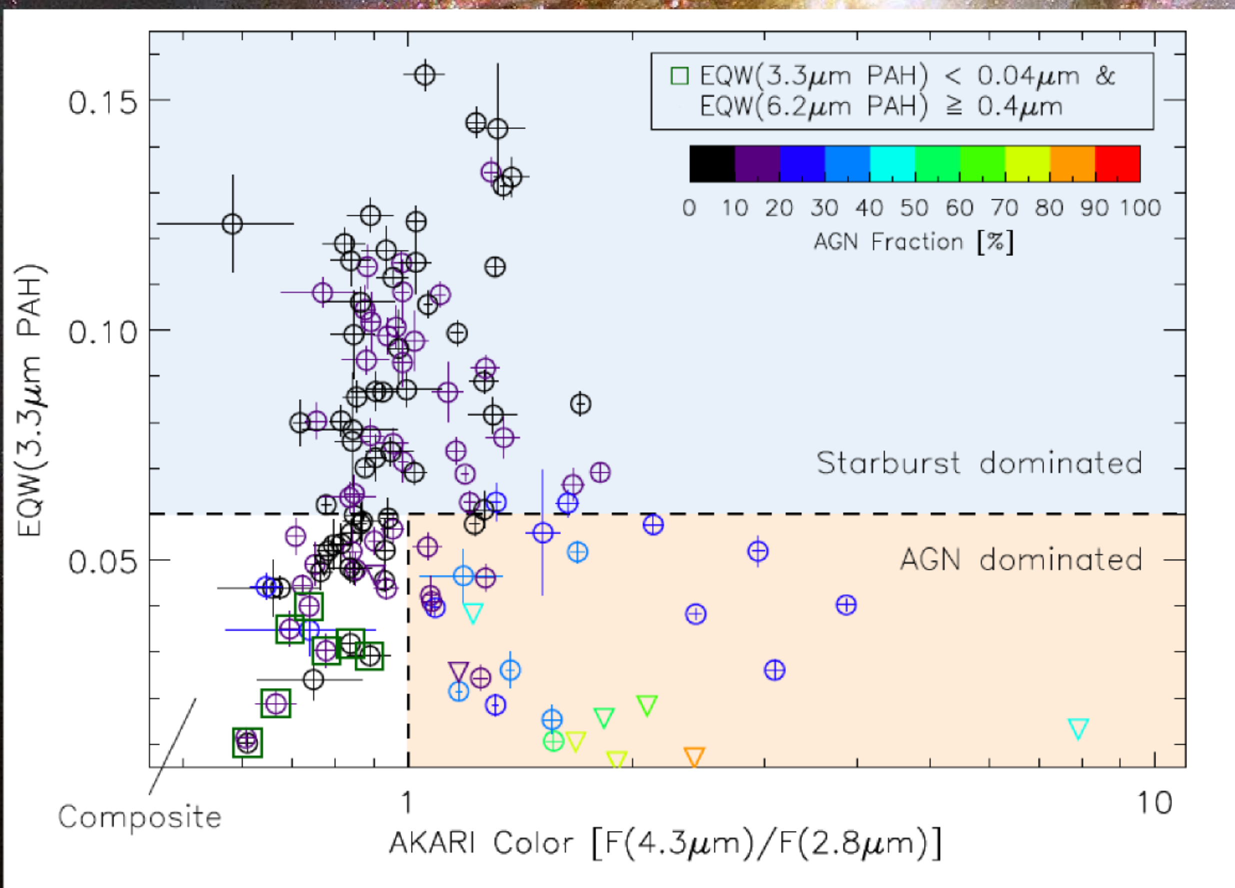
AstroPAH

A Newsletter on Astronomical PAHs

Issue 59 • June 2019



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Editorial

Dear Colleagues,

We are pleased to publish our issue 59 for the month of June. Approximately two months ago, the first IAU Symposium on Laboratory Astrophysics titled ”From Observations to Interpretation” took place in Cambridge, UK. We have the pleasure of sharing with you a summary of the Symposium in our In Focus section, written by Dr. Farid Salama, Chair of the SOC. Proceedings from the Symposium will be published later this year, and we will be sure to keep you informed on that.

In our Abstracts section, we have featured a number of new publications related to interstellar dust modeling using new dynamical constraints and radiative torque disruptions, H II regions associated with infrared ring nebulae and the energy relaxation time following UV absorption of polyacenes.

Abstract submissions are still open for the 26th International Symposium on Polycyclic Aromatic Compounds (ISPAC). More information on the conference website: https://www.oru.se/ISPAC2019.

We hope you enjoy reading our newsletter and look forward to seeing you again next month.

Enjoy reading our newsletter!

The Editorial Team

Next issue: 18 July 2019.
Submission deadline: 5 July 2019.

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Contents

PAH Picture of the Month

Extragalactic astronomers use the strength of PAH bands to understand the nature of galaxies near and far. This month's cover shows how the equivalent width (or the area) of the 3.3 μm PAH feature in combination with the strength of a galaxy emission at 4.3 and 2.8 μm can help discriminating between the presence of an Active Galactic Nuclei (AGN) or increased star formation activity (Starburst) in Luminous Infrared Galaxies, observed by the AKARI satellite. For more information, "The AKARI 2.5-5 micron Spectra of Luminous Infrared Galaxies in the Local Universe", by H. Inami et al, 2018, A&A, A130, 27.

Credits: H. Inami and coauthors

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First IAU Symposium on Laboratory Astrophysics

From Observations to Interpretation - IAU S350

by Farid Salama
Chair of the SOC

Laboratory astrophysics is the Rosetta stone that enables astronomers to understand and interpret the cosmos. Astronomy is primarily an observational science detecting photons generated by atomic, molecular, chemical, and condensed matter processes. Our understanding of the universe also relies on knowledge of the evolution of matter (nuclear and particle physics) and of the dynamical processes shaping it (plasma physics). Planetary science, involving *in-situ* measurements of solar system bodies, requires knowledge from physics, chemistry, and geology. Exploring the question of life elsewhere in the Universe draws on all the above as well as biology. Hence, our quest to understand the cosmos rests firmly on theoretical and experimental research in many different branches of science. Taken together, these astrophysically motivated theoretical and experimental studies are known as **Laboratory Astrophysics**.

The IAU Symposium 350, "Laboratory Astrophysics: From observations to Interpretation" was organized by the IAU Commission B5 and was the first in a series of IAU Symposia that will be regularly held from now on on this topic. The goal of the Symposium was to *help bridge Laboratory Astrophysics and Astrochemistry with Astronomy by bringing together expert providers and users of laboratory and astronomical data.*

This multidisciplinary meeting brought together astronomers with theoretical-, and experimental chemists and physicists to discuss the state-of-the-art research in their respective disciplines and how their combined expertise can address important open questions in modern astronomy and astrophysics.

Active researchers in observational astronomy, space missions, experimental and theoretical laboratory astrophysics and astrochemistry were invited to gather and discuss the major topics and challenges that face today's Astronomy with the hope that interactions between researchers will result in a solid roadmap for future research that will lead to advances in our understanding of astronomical observations and guide the design of future observational instruments.

To serve this purpose, a broad scope of topics was selected for this inaugural event. The scientific discussions were divided between the major topics and thematic areas encompassing the breadth of the field of Laboratory Astrophysics. The astronomy topics covered spanned from **star- and planet-formation** through stellar populations to **extragalactic chemistry** and **dark matter**, complimented by chemistry and physics reaching from **fundamental atomic and molecular spectroscopy**, through **surface reaction dynamics, catalysis, nuclear processes and high-energy physics**, including fundamental processes in some of the most extreme environments we can imagine.

The first IAU Symposium on Laboratory Astrophysics was held from April 14 to 19, 2019, in the beautiful and science-enticing environment of Jesus College in Cambridge, UK, and was attended by over 170 participants, which presented close to 160 presentations between talks and posters. In addition to its rich science program, the symposium was complemented with a series of education outreach events that included exhibits and activities for school children organized by Dr. Sabrina Goertner (LOC), as well as two public presentations: one by Dr. Kimberly Ennico Smith on Dust, Ice and Water, and one by Dr. Helen Fraser on How to Build a Planet in the Lab.

Finally, coincidentally, and also very fittingly, the *first* IAU Symposium on Laboratory Astrophysics was held the year the IAU celebrates its 100th anniversary! Tribute was given to this important event by Dr. Ewine van Dishoeck, President of the IAU, who participated to the Laboratory Astrophysics Symposium and gave a special presentation on the 100 Years of the IAU and the associated events that are being held all year long to celebrate this important event for astronomy. She also gave a separate presentation on ”Women in Astronomy”, summarizing the results of the recent IAU survey on this topic and the initiatives that are being taken by the IAU to increase the number of its female members.

JESUS COLLEGE
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Acknowledgments

The Symposium was primarily sponsored by the IAU with additional support from NASA, the Open University, PCMI, ESA, PNP, EuroPLANET, and many others. The author would like to thank the members of the SOC who helped put together a strong and enticing science program and the members of the LOC who did an amazing work in making the Symposium run smoothly and flawlessly.

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References

The Proceedings will be published in: Salama, F., Fraser, H, Linnartz, H. (Eds.), "IAUS 350: First IAU Symposium on Laboratory Astrophysics: From Observations to Interpretation", IAU Proceedings, Cambridge University Press, Cambridge, 2019

Abstracts

Rotational disruption of dust grains by radiative torques in strong radiation fields

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Massive stars, supernovae, and kilonovae are among the most luminous radiation sources in the Universe. Observations usually show near- to mid-infrared (NIR-MIR, $\lambda \approx$ 1-5 μm) emission excess from H II regions around young massive star clusters. Early-phase observations in optical-to-NIR wavelengths of type Ia supernovae also reveal unusual properties of dust extinction and dust polarization. The most common explanation for such NIR-MIR excess and unusual dust properties is the predominance of small grains (size a $\lesssim$ 0.05 μm) relative to large grains ($a \gtrsim$ 0.1 μm) in the local environment of these strong radiation sources. However, why small grains might be predominant in these environments is unclear. Here we report a mechanism of dust destruction based on centrifugal stress within extremely fast-rotating grains spun-up by radiative torques, which we term radiative torque disruption (RATD). We find that RATD can disrupt large grains located within a distance of about a parsec from a massive star of luminosity $L \approx 10^4\ L_\odot$, where $L_\odot$ is the solar luminosity, or from a supernova. This disruption effect increases the abundance of small grains relative to large grains and successfully reproduces the observed NIR-MIR excess and anomalous dust extinction/polarization. We apply the RATD mechanism for kilonovae and find that dust within about 0.1 parsec would be dominated by small grains. Small grains produced by RATD can also explain the steep far-ultraviolet rise in extinction curves towards starburst and high-redshift galaxies, and the decrease of the escape fraction of Lyman α photons from H II regions surrounding young massive star clusters.

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Nature Astronomy, Volume 3 Issue 5, May 2019.

https://www.nature.com/articles/s41550-019-0763-6

https://astronomycommunity.nature.com/users/254231-thiem-hoang/posts/48615-discovery-of-a-new-mechanism-to-destroy-dust-grains-in-strong-radiation-fields

Dust Rotational Dynamics in C-shocks: Rotational Disruption of Nanoparticles by Stochastic Mechanical Torques and Spinning Dust Emission

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Polycyclic aromatic hydrocarbons (PAHs) and nanoparticles are expected to play an important role in many astrophysical processes due to their dominant surface area, including gas heating, chemistry, star formation, and anomalous microwave emission. In dense magnetized molecular clouds where C-shocks are present, PAHs and nanoparticles are widely believed to originate from grain shattering due to grain-grain collisions. The remaining question is whether these nanoparticles can survive in the dense and hot shocked regions, and how to constrain their size and abundance with observations. In this paper, we present a new mechanism to destroy nanoparticles in C-shocks based on centrifugal stress within rapidly spinning nanoparticles spun up by stochastic atomic bombardment, which is termed rotational disruption. We find that, due to supersonic neutral gas-charged grain drift in C-shocks, nanoparticles can be spun up to suprathermal rotation by stochastic torques exerted by supersonic neutral flow. The resulting centrifugal stress within suprathermally rotating nanoparticles can exceed the maximum tensile strength of grain material (S_{max}), resulting in rapid disruption of nanoparticles smaller than $a \sim 1$ nm for $S_{max} \sim 10^9$ erg cm^{-3}. The proposed disruption mechanism is shown to be more efficient than thermal sputtering in controlling the lower cutoff of grain size distribution in C-shocks. We model microwave emission from spinning nanoparticles in C-shocks subject to supersonic neutral drift and rotational disruption. We find that suprathermally rotating nanoparticles can emit strong microwave radiation, and both peak flux and peak frequency increase with increasing shock velocity. We suggest spinning dust as a new method to constrain nanoparticles and trace shock velocities in shocked dense regions.

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The Astrophysical Journal, 877:36 (16pp), 2019 May 20.

https://iopscience.iop.org/article/10.3847/1538-4357/ab1845

A Dynamical Constraint on Interstellar Dust Models from Radiative Torque Disruption

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Interstellar dust is an essential component of the interstellar medium (ISM) and plays critical roles in astrophysics. Achieving an accurate model of interstellar dust is therefore of great importance. Interstellar dust models are usually built based on observational constraints such as starlight extinction and polarization, but dynamical constraints such as grain rotation are not considered. In this paper, we show that a newly discovered effect by Hoang et al., so-called RAdiative Torque Disruption (RATD), can act as an important dynamical constraint for dust models. Using this dynamical constraint, we derive the maximum size of grains that survive in the ISM for different dust models, including contact binary, composite, silicate core and amorphous carbon mantle, and compact grain model for the different radiation fields. We find that the different dust models have different maximum sizes due to their different tensile strengths, and the largest maximum size corresponds to the compact grains with the highest tensile strength. We show that the composite grain model cannot be ruled out if constituent particles are very small with radius $a_p <$25 nm, but large composite grains would be destroyed if the particles are large with $a_p >$50 nm. We suggest that grain internal structures can be constrained with observations using the dynamical RATD constraint for strong radiation fields such as supernova, nova, or star-forming regions. Finally, our obtained results suggest that micron-sized grains perhaps have compact/coremantle structures or have composite structures but are located in regions with slightly higher gas density and weaker radiation intensity than the average ISM.

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The Astrophysical Journal, 876:13 (10pp), 2019 May 1.

https://iopscience.iop.org/article/10.3847/1538-4357/ab1075/meta

Infrared Photometric Properties of Inner and Outer Parts of H II regions

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The fact that infrared ring nebulae (IRRNs) are frequently associated with H II regions, provides us the opportunity to study dust at the interface between ionized and neutral gas. In this paper, we analyze the infrared radiation in the range from 8 to 500 μm in outer and inner parts of 32 IRRNs showing round shape. We aim to determine the morphology of these objects and possible dust evolution processes on the base of the comparison of IR radiation towards the ionized and neutral regions. We calculate six slopes between adjacent wavelengths in their spectral energy distributions to trace the difference in the physical conditions inside and outside ionized regions. Using the data on these 32 objects we show that their morphology is likely 3D spherical rather than 2D plane-like. The slope between 70 and

160 μm is the most appropriate tracer of the dust temperature in the outer envelope. The larger 8-to-24 μm intensity ratio is associated with smaller intensities at mid-IR indicating that the PAHs may indeed be generated due to larger grain destruction. These data are important for the subsequent theoretical modeling and determining the dust evolution in H II regions and their envelopes.

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Accepted for publication in Research in Astronomy and Astrophysics (RAA)

https://arxiv.org/abs/1905.11077

http://www.raa-journal.org/docs/papers_accepted/2019-0068.pdf

Non-adiabatic molecular dynamics investigation of the size dependence of the electronic relaxation in polyacenes

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The Tully's fewest switches surface hopping algorithm is implemented within the framework of the time-dependent density functional based tight binding method (TD-DFTB) to simulate the energy relaxation following absorption of a UV photon by polycyclic aromatic hydrocarbons (PAHs). This approach is used to study the size effect on the ultrafast dynamics in excited states for a special class of PAH species called polyacenes. We determine the dynamical relaxation times and discuss the underlying mechanisms. Our results show that there is a striking alternation in decay times of the brightest singlet state for neutral polyacenes with 3 to 6 aromatic cycles. The alternation corresponds to an order-of-magnitude variation between roughly 10 and 100 fs and is correlated with a qualitatively similar alternation of energy gaps between the brightest state and the state lying just below in energy.

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Phys. Chem. Chem. Phys. (2019)

https://pubs.rsc.org/en/content/articlelanding/2019/cp/c9cp00603f/