2022 Poster Competition

Wednesday, 18 October 2023 - Wednesday, 18 October 2023

Book of Abstracts

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Modeling meteorite crater by impacting melted tin on sand

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By impacting a granular bed by steel balls and liquid drops, previous researchers focused mainly on the morphology of impact craters. [1-2] To
mimic the heated exterior of a meteorite, we adopt the melted tin. A high-speed camera allows us to follow step by step the fiery interaction between melted
tin and sand, as manifested in PIV and CNN, and monitor their deformation. Kinetic energy, temperature and diameter of the projectile are used to build
phase diagrams for the morphology of both players. We are able to reproduce simple and complex craters based on the morphology. By employing the
feature detection with deep learning, we can further verify that the mechanism for generating a central peak in our pearl crater is indeed similar to that in
complex craters. How the width and depth of crater are correlated and separately vary with kinetic energy are shown to change with the granular size. For
our finest sand, the pearl and cookie craters share the same relationship for a simple crater, while the snowflake crater behaves more like a complex one.
Geological compilations of crater data are clearly mixed with different meteorite energy and temperature. Thus, our work is not confined to reproducing
real observations, but has the potential of debunking artifacts.

1 F. Pacheco-Va´zquez et al., Impact Craters in Granular Media: Grains against Grains, PRL 107, 218001 (2011).
[2] Runchen Zhao et al., Granular impact cratering by liquid drops: Understanding raindrop imprints through an
analogy to asteroid strikes, PNAS 112, 342 (2014).

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Poster section / 2

Statistical constraints on primordial globular cluster formation

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Globular clusters (GC) are the oldest known astronomical objects in the universe. Discovered about two hundred years ago, the initial conditions that give rise to GCs are still mysterious. Significant progress has been made in the last decade: a clear correlation has been found between the total number (or mass) of GCs in a galaxy and the mass of its host dark matter halo, which provides an important constraint on models; meanwhile, detailed hydrodynamical models of GC populations in a cosmological context have shown that substantial fraction may have formed in the turbulent ISM of massive, gas-rich galaxies at $1 < z < 4$. However, a subdominant population of primordial GCs may also have formed as 'nuclear clusters' in low-mass dark matter halos, before the epoch of reionization. If primordial clusters exist, their cosmic abundance may be a useful probe of the earliest epoch of galaxy formation, and hence of cosmology (as suggested by \cite{Peebles1984}). Therefore, answering the formation of GCs in the extreme context of a high redshift universe is important. In this work, we apply parameterized models of primordial GC formation to Extended Press-Schechter merger trees and attempt to constrain their allowed parameter space through statistical comparison

to the observed relation between cluster number and halo mass. We found that the primordial GC formation process can answer for the abundance of GCs in dark matter halos at mass $\leq 10^{10} M_{\odot}$. On the higher mass halos, we need a process of GC disruption to keep less than 50% of GCs in these host halos, assuming the observational data from \cite{Harris2013}.

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Twisted layer structure: Electronic properties

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Since 2011 the low energy continuum model of twisted bilayer graphene(TBG) has been solved, the researches about TBG has never decayed.
In 2012,the tight binding model of TBG was proposed, short after, more and more van der Waals hetero-structure were gradually synthesized from experiments,and the theory also predicted many possible new materials and structures, including derivatives of graphene and popular two dimensional materials such as hexagonal boron nitride (hBN) and transition-metal dichalcogenide (TMD). However, for the twisted bilayer structure, there are relatively few examples of DFT calculations. The reason is that complex structures are not easy to build and too many atoms are difficult to DFT calculations. TBG is the most researched 2d material. In addition to TBG, we have also studied the electronic structure of other 2d materials after rotation. We hope that by exploring the energy bands, we can preliminarily judge whether they are magnetic or superconducting. Possibly, this will be a very important step for twistronics, because van der Waals forces will play an important role in this, and the effect on the electronic structure of superlattices with different sizes by changing the angle is very significant.

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The molecular gas kinematics in the host galaxy of non-repeating FRB 180924B

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Fast radio bursts (FRBs) are millisecond-duration transients with large dispersion measures. The origin of FRBs is still mysterious. One of the methods to comprehend FRB origin is to probe the physical environments of FRB host galaxies. Mapping molecular-gas kinematics in FRB host galaxies is critical because it results in star formation that is likely connected to the birth of FRB progenitors. However, most previous works of FRB host galaxies have focused on its stellar component. Therefore, we, for the first time, report the molecular gas kinematics in the host galaxy of the non-repeating FRB 180924B at $z = 0.3216$. Two velocity components of the CO (3-2) emission line are detected in its host galaxy with the Atacama Large Millimeter/submillimeter Array (ALMA): the peak of one component (-155.40 km s^{-1}) is near the centre of the host galaxy, and another (-7.76 km s^{-1}) is near the FRB position. The CO (3-2) spectrum shows asymmetric profiles with $A_{\rm peak} = 2.03 \pm 0.39$,

where A_{peak} is the peak flux density ratio between the two velocity components. The CO (3-2) velocity map also indicates an asymmetric velocity gradient from -180 km s^{-1} to 8 km s^{-1}. These results indicate a disturbed kinetic structure of molecular gas in the host galaxy. Such disturbed kinetic structures are reported for repeating FRB host galaxies using HI emission lines in previous works. Our finding indicates that non-repeating and repeating FRBs could commonly appear in disturbed kinetic environments, suggesting a possible link between the gas kinematics and FRB progenitors.

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Star Formation and Fragmentation in Dense Cores in Orion A

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When dense cores in molecule clouds collapse and form protostars, they may fragment into some smaller structures and develop multiple systems. However, the key mechanisms that control fragmentation remain unclear observationally. In this project, we try to answer this question by analyzing the physical conditions(i.e.: density, turbulence, magnetic field, Jeans instability) of dense cores in Orion A and comparing the environment of single systems and binary/multiple systems.

By comparing the dense cores that form single protostar and dense cores that form binary/multiple system, we found that the dense cores with a greater core size-to-jeans length ratio or greater core mass-to-jeans mass tend to be more unstable and were prone to fragment into binary/multiple system. Additionally, the cores with single protostars tend to have larger ratio of P_B/u_G (magnetic pressure/gravitational energy density), which implies that magnetic field may suppress the fragmentation of dense cores.

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Sparse Edge Encoder for Natural Images

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Inspired by the diffusive reflection for natural imaging, we proposed Sparse Edge Encoder(SEE) to represent the correlation between local nearing pixels for the natural images, the corresponding image charges representation points out the singularities that violate the fundamental assumption, provides the pixel hierarchy within a natural image. The experiments show that great enhancements(larger than 200%) of Hoyer Sparseness are show up after the SEE operation for different natural images. We also demonstrate successful experiments for dimension reduction that reconstuct images with PSNR value around 30dB by less than 35% total pixels, indicating that useful information compressed to the image charges which mainly appear at the edges only,
the distribution of image charges are the key components to affect the image data in pixel representation. To demonstrate this property, an interesting experiment for anomaly detection based on SEE is presented, which shows that texture information is extracted by the distribution of bulk charges.

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Nonclassical Motional State Excitation in Bose-Einstein Condensates

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We present the experimental observation of macroscopic excited motional states in Bose-Einstein condensates. The interference of the states exhibits a non-smooth density distribution. Unlike the conventional collective oscillation modes, the perturbative approach is not applicable for its dynamics. In our protocol of the trap frequency jumping, the condensate is self excited by lowering the potential well allowing it to release the chemical potential to the kinetic energy. To observe and enhance the obtained effects, we transferred BECs to a quasi-2D potential well with a chirped trap frequency, and then effectively converted the 3D atomic ensemble to a sequence of 2D slices. We have observed the cloud deformation as a non-Gaussian wave packet, and then its revival. The excited atomic cloud undergoes coherent superposition and possesses collective oscillation among excited motional states. The momentum space observation (time-of-flight imaging) provides a strong implication of squeezing. Our method can be applied for the matter-wave propagation and manipulation of nonclassical motional states.

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Toward Un-hackable Quantum Network

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Quantum key distribution (QKD) aims to provide an information theoretically secure way to distribute secret keys. However, practical devices may not follow the theoretical assumptions, which leaves a backdoor for eavesdropper to exploit. Single photon detectors are considered to be the most vulnerable part in QKD systems. Measurement device independent (MDI) protocol provides a way to remove all detector side channels by introducing an untrusted relay performing Bell-state measurement jointly on the prepared states. The relay can also serve as the central node of a quantum network, which allows quantum communication without trusted relay or point-to-point communication which is hard to scale up.

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A T-dwarf Candidate from JWST Early Release NIRCam Data

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A T-dwarf Candidate from JWST Early Release NIRCam Data

We found an early T-dwarf, CEERS-BD1, with the effective temperature of Teff ~1300K. An estimated distance of 4.92±0.32kpc shows it could possibly be located in the thick disk or galactic halo. Further spectroscopic observations such as JWST NIRSpec would be important to confirm the properties.

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Source counts at 7.7 to 21 micron in CEERS field with JWST

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Source counts at 7.7 to 21 micron in CEERS field with JWST

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Self-Assembly of Magnetic Atoms on Stanene.

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Self-Assembly of Magnetic Atoms on Stanene

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Polycyclic aromatic hydrocarbon (PAH) luminous galaxies in JWST CEERS data

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Polycyclic aromatic hydrocarbon (PAH) luminous galaxies in JWST CEERS data

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Finding dusty AGNs from JWST ERO with mid-infrared photometry

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Active galactic nuclei (AGNs) are one of the most intriguing and challenging phenomena in modern astronomy. The nature of the interaction between AGNs and their host galaxies remains an unsolved question. Therefore, conducting an AGN census is crucial to AGN research. However, many AGNs are obscured by their environment, which can block UV and optical observations due to the dusty torus surrounding the central supermassive black hole (SMBH). To overcome this challenge, mid-infrared (IR) surveys have emerged as a valuable tool for identifying obscured AGNs, as the obscured light is re-emitted in this range. In this work, we investigate AGN candidates in the Cosmic Evolution Early Release Science (CEERS) fields selected by the SED models from CIGALE. We report the relationships between the AGN luminosity contribution and AGN number fraction with redshift and total infrared luminosity, respectively. Our findings show that both the AGN luminosity contribution and AGN number fraction exhibit increasing trends as a function of redshift in certain total IR luminosity bins. Furthermore, with the high sensitivity of the James Webb Space Telescope (JWST), we extend the previous results on ULIRGs in Wang et al. (2020) to less luminous AGNs.

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Revisiting the Mysterious Origin of FRB 20121102A with Machine-learning Classification

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Revisiting the Mysterious Origin of FRB 20121102A with Machine-learning Classification

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Galaxy source counts at 7.7 μm, 10 μm and 15 μm with the James Webb Space Telescope

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Galaxy source counts at 7.7 μm, 10 μm and 15 μm with the James Webb Space Telescope

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In-depth analysis of music structures as a self-organized network

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In-depth analysis of music structures as a self-organized network

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Discovering missing information in Quantum theory via deep learning network

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Discovering missing information in Quantum theory via deep learning network