# Astronomy & Physics News

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100 Million Stars in the Andromeda galaxy.


Department of Physics—United Arab Emirates University

*Weekly news from around the world compiled by Dr. Ilias Fernini*


**Inside this issue:**



## Breakthrough lights up metamaterials

City College of New York led-team has successfully demonstrated how to both enhance light emission and capture light from metamaterials embedded with light emitting nanocrystals. The breakthrough, headed by physicist Dr. Vinod Menon, could lead to a range of applications including ultrafast LEDs, nanoscale lasers and efficient single photon sources.

In the demonstration, the team used metamaterials having hyperbolic dispersion to enhance the light emission properties of the nanocrystals and simultaneously engineered an efficient light extraction scheme.

"The idea of metamaterials in the context of optics is that you can manipulate light and decide how you want it to behave in this medium," said Professor Menon a photonics expert whose specialty includes control of light-matter interaction at the nanoscale.

While enhancement in light emission from such systems was shown by different groups, including Dr. Menon's, in the past, they were not useful since light did not come out easily from them, making their practical application an issue. The present work alleviates this issue and takes the first step towards developing practical light emitters based on metamaterials...***Read More***...

*File Image.*

## Extending Einstein's spooky action for use in quantum networks

An international team, including researchers from Swinburne University of Technology, has demonstrated that the 1935 Einstein-Podolsky-Rosen (EPR) quantum mechanics paradox may be extended to more than two optical systems, paving the way for exploration of larger quantum networks.

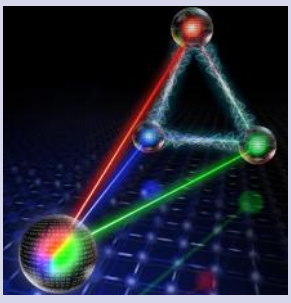
Quantum mechanics is the theory used to describe nature's smallest systems, like atoms or photons.

The EPR paradox pointed out that two well-separated systems can have a strange type of quantum connection, so that what happens in one system seems to immediately affect the other.

This connection has recently been called 'EPR steering entanglement'.

EPR steering is the nonlocality – what Albert Einstein called 'spooky actions at a distance' – associated with the EPR paradox and has traditionally been investigated between only two parties.

An experiment performed by researchers from the Australian National University (ANU) and Tianjin University supports the predictions of theoretical work developed by researchers at Swinburne and Peking University...***Read More***...



*File Image.*

## Novel superconducting hybrid crystals developed

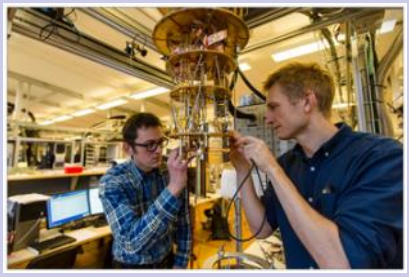
A new type of nanowire crystals that fuses semiconducting and metallic materials on the atomic scale could lay the foundation for future semiconducting electronics. Researchers at the Univ. of Copenhagen are behind the breakthrough, which has great potential.

The development and quality of extremely small electronic circuits are critical to how and how well future computers and other electronic devices will function. The new material, comprised of both a semiconductor and metal, has a special superconducting property at very low temperatures and could play a central role in the development of future electronics.

"Our new material was born as a hybrid between a semiconducting nanowire and its electronic contact. Thus we have invented a way to make a perfect transition between the nanowire and a superconductor. The superconductor in this case is aluminium," says Assoc. Prof. Thomas Sand Jespersen. "There is great potential in this." Jespersen has worked in the field for more than 10 years, ever since research into nanowire crystals has existed at the Nano-Science Center at the Niels Bohr Institute.

**Nanowire and contact formed at the same time**

Nanowires are extremely thin nanocrystal threads used in the development of new electronic components, like transistors and solar cells. Part of the challenge of working with nanowires is creating a good transition between these nanowires and an electrical contact to the outside world. Up until now, researchers, not just ...***Read More***...



*Thomas Sand Jespersen and Peter Krogstrup, here seen in the laboratory at the Center for Quantum Devices, Niels Bohr Institute, where the research in nanowire crystals are taking place. The nanowire crystals may lie the foundation for future electronics, such as quantum computation and solar cells.*

## Gold nanoparticles show promise for early detection of heart attacks

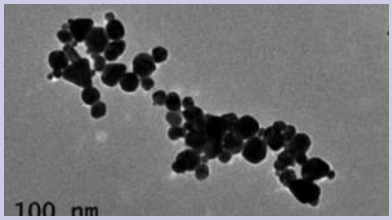
NYU Polytechnic School of Engineering professors have been collaborating with researchers from Peking University on a new test strip that is demonstrating great potential for the early detection of certain heart attacks.

Kurt H. Becker, a professor in the Department of Applied Physics and the Department of Mechanical and Aerospace Engineering, and Wei-Dong Zhu, a research associate professor in the Department of Mechanical and Aerospace Engineering, are helping develop a new colloidal gold test strip for cardiac troponin I (cTn-I) detection. The new strip uses microplasma-generated gold nanoparticles (AuNPs) and shows much higher detection sensitivity than conventional test strips. The new cTn-I test is based on the specific immune-chemical reactions between antigen and antibody on immunochromatographic test strips using AuNPs.

Compared to AuNPs produced by traditional chemical methods, the surfaces of the gold nanoparticles generated by the microplasma-induced liquid chemical process attract more antibodies, which results in significantly higher detection sensitivity.

cTn-I is a specific marker for myocardial infarction. The cTn-I level in patients experiencing myocardial infarction is several thousand times higher than in healthy people. The early detection of cTn-I is therefore a key factor of heart attack diagnosis and therapy.

The use of microplasmas to generate AuNP is yet another application of the ...***Read More***….




*Microscopic view of microplasma-gold nanoparticles on a new, highly sensitive, test strip that enables early detection of heart attacks.*

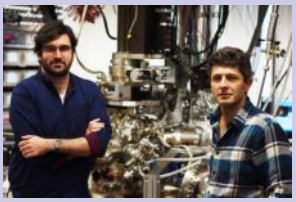
## Charge instability detected across all types of copper-based superconductors

Superconductors made of copper-oxide ceramics called cuprates are capable of conducting electricity without resistance at record-high temperatures—but still only at about one-third of room temperature. They also require cooling with liquid nitrogen, which is not practical for many potential applications, such as smart power grids, high-precision magnetometry, advanced power storage units and imaging systems.

A phenomenon called charge ordering appears to compete with superconductivity and reduce the temperature at which cuprates demonstrate superconducting properties.

The behavior, which had been previously observed in a class of cuprates known as hole-doped cuprates, has now been detected in electron-doped cuprate superconductors for the first time. Doping involves adding impurities to the cuprate materials to produce either electrons or holes, which spur them to exhibit unusual behaviors, such as superconductivity.

The findings, published Jan. 15, 2015 online in the journal Science, suggest that charge order may be a universal feature of high-temperature superconductors. By uncovering the specific mechanism for superconductivity in cuprates, researchers hope to synthesize other materials that can superconduct at room temperature. Physicists from the University of British Columbia and the University of Maryland performed the study. "This study's surprising results indicate that charge order must play a very important, as yet unknown, role in high-temperature ...***Read More***….



*Eduardo H. da Silva Neto and Andrea Damascelli at UBC's Quantum Matter Institute. Credit: Credit: University of British Columbia.*

## Astronomers seek widest view ever of the universe with new telescope

At the annual meeting of the American Astronomical Society last week, the booth devoted to a revolutionary new telescope called the LSST got a lot of traffic.

Staffed by scientists from the University of Washington and other institutions, the display didn't feature sexy pictures of galaxies or nebulae, but it did include a sign that said LSST is hiring.

That was welcome news in a field where jobs can be hard to come by. It's also proof that after decades of planning and fundraising, a dream nurtured in part by UW and backed by Seattle billionaires is well on its way to reality.

On Saturday in Tuscon, Ariz., former Microsoft executive Charles Simonyi joined other luminaries to celebrate completion of the telescope's 20-ton mirror assembly, which includes the largest convex mirror ever made. Simonyi, who has twice visited the International Space Station as a tourist, put up $20 million for the mirror. His former boss Bill Gates chipped in $10 million.

Construction of the $700 million telescope will begin in earnest this spring on a mountaintop in Chile's Atacama Desert.

"We hope to get the first data, the first light, in 2019," said UW astronomer Zeljko Ivezic, project scientist for the telescope.

LSST stands for Large Synoptic Survey Telescope, a name even astronomers agree is clunky for what has been described as the world's most powerful sky-mapping machine. While most telescopes can take only snapshots of a narrow sliver of space, LSST will scan the heavens continuously in wide swaths.

The telescope will produce an image of the entire southern sky every three days - a feat that would take the Hubble Space Telescope 120 years to accomplish once….***Read More***...

*Credit: LSST*

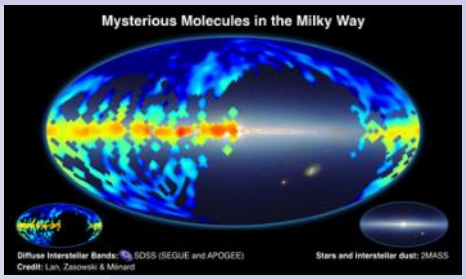
## Map of mysterious molecules in our galaxy shed new light on century-old puzzle

By analyzing the light of hundreds of thousands of celestial objects, Johns Hopkins Univ. astronomers from the Sloan Digital Sky Survey (SDSS) have created a unique map of enigmatic molecules in our galaxy that are responsible for puzzling features in the light from stars.

The map was unveiled Jan. 8 at the 225th meeting of the American Astronomical Society in Seattle. "Seeing where these mysterious molecules are located is fascinating," said Brice Ménard, a professor in the Dept. of Physics & Astronomy at The Johns Hopkins Univ.

Gail Zasowski, another Johns Hopkins astronomer who played a key role in the project, added, "This new map required analyzing huge amounts of data and using the power of statistical analyses."

These puzzling features in the light from stars, which astronomers call "Diffuse Interstellar Bands" (DIBs), have been a mystery ever since they were discovered by astronomer Mary Lea Heger of Lick Observatory in 1922. While analyzing the light from stars, she found unexpected lines that were created by something ...***Read More***...




*Credit: John Hopkins Univ.*

## Astronomers are Predicting at Least Two More Large Planets in the Solar System

Could there be another Pluto-like object out in the far reaches of the Solar System? How about two or more?

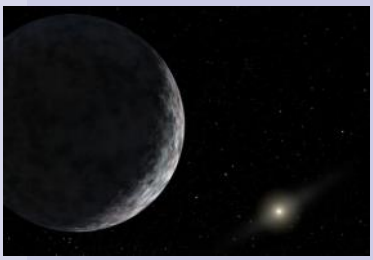
Earlier this week, we discussed a recent paper from planet-hunter Mike Brown, who said that while there aren't likely to be any bright, easy-to-find objects, there could be dark ones "lurking far away." Now, a group of astronomers from the UK and Spain maintain at least two planets must exist beyond Neptune and Pluto in order to explain the orbital behavior of objects that are even farther out, called extreme trans-Neptunian objects (ETNO).

We do know that Pluto shares its region Solar System with more than 1500 other tiny, icy worlds along with likely countless smaller and darker ones that have not yet been detected.

In two new paper published this week, scientists at the Complutense University of Madrid and the University of Cambridge noted that the most accepted theory of trans-Neptunian objects is that they should orbit at a distance of about 150 AU, be in an orbital plane – or inclination – similar to the planets in our Solar System, and they should be randomly distributed.

But that differs from what is actually observed. What astronomers see are groupings of objects with widely disperse distances (between 150 AU and 525 AU) and orbital inclinations that vary between 0 to 20 degrees.

"This excess of objects with unexpected orbital parameters makes us believe that some invisible forces are altering the distribution of the orbital elements of the ETNO," said Carlos de la Fuente Marcos...***Read More***...



*At least two unknown planets could exist in our solar system beyond Pluto. / Credit: NASA/JPL-Caltech.*

## Physics Department

*College of Science - United Arab Emirates University*
*POB 15551*
*Al-Ain*
*United Arab Emirates*

*Phone: 00-971-3-7136336*
*Fax: 00-971-3-713-6909*
*E-mail: physics@uaeu.ac.ae*

http://www.cos.uaeu.ac.ae/en/departments/physics/index.shtml

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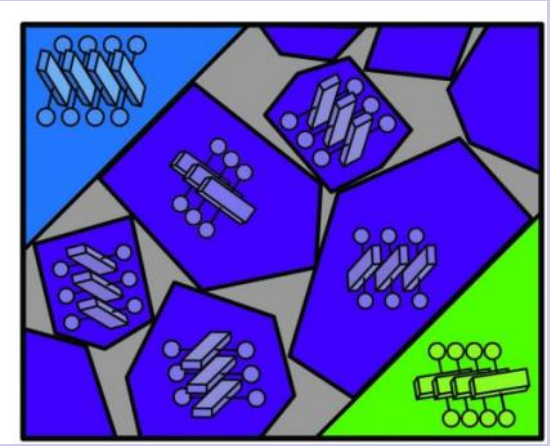


*Sketch of organic semiconductor thin film shows that the interfacial region between larger domains (blue and green) consists of randomly oriented small, nano-crystalline domains (purple). Credit: Naomi Ginsberg, Berkeley Lab*

## *Solving an organic semiconductor mystery*

Organic semiconductors are prized for light emitting diodes (LEDs), field effect transistors (FETs) and photovoltaic cells. As they can be printed from solution, they provide a highly scalable, cost-effective alternative to silicon-based devices. Uneven performances, however, have been a persistent problem. Scientists have known that the performance issues originate in the domain interfaces within organic semiconductor thin films, but have not known the cause. This mystery now appears to have been solved.

Naomi Ginsberg, a faculty chemist with the U.S. Department of Energy (DOE)'s Lawrence Berkeley National Laboratory and the University of California (UC) Berkeley, led a team that used a unique form of microscopy to study the domain interfaces within an especially high-performing solution-processed organic semiconductor called TIPS-pentacene...***Read More***...

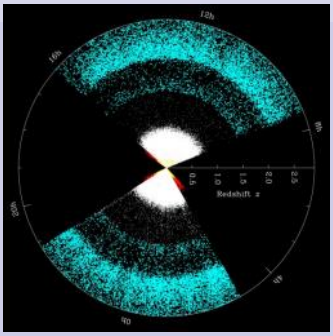
## *Like a BOSS: How Astronomers are Getting Precise Measurements of the Universe's Expansion Rate*

Astrophysicists studying the expansion of the Universe with the largest galaxy catalogs ever assembled are ushering in an exciting era of precision cosmology. Last week, the Sloan Digital Sky Survey (SDSS) issued its final public data release, and scientists working in its largest program, the Baryon Oscillation Spectroscopic Survey (BOSS) also presented their final results at the American Astronomical Society meeting in Seattle, Washington.

By mapping over 10,000 square degrees — 25% of the sky — BOSS is "measuring our universe's accelerated expansion with the world's largest extragalactic redshift survey," according to SDSS-III Director Daniel Eisenstein of the Harvard-Smithsonian Center for Astrophysics. The BOSS results include new and precise measurements of the universe's expansion rate (called the "Hubble constant") and matter density, which includes dark matter, stars, gas, and dust.

BOSS conducted its observations at 2.5-meter Sloan Foundation Telescope at Apache Point Observatory in New Mexico, producing spectra and spatial positions for 1.5 million galaxies and 300,000 quasars in a volume equivalent to a cube with length 8.5 billion light-years on a side (see image above). Astronomers used this rich dataset to map the objects' distributions and to detect the characteristic scale imprinted by baryon acoustic oscillations in the early universe. Sound waves propagate outward with time, like ripples spreading in a pond, and are indicated by a large-scale clustering signal in the positions of galaxies relative to each other (see illustration below). By analyzing this signal at different times, it is possible to study the behavior of the mysterious "dark energy" causing the accelerating expansion of the universe.

In BOSS's final results, hundreds of scientists in the international collaboration measured this scale with unprecedented precision. In particular, Ashley Ross from Ohio State University presented results that demonstrated the power of combining an analysis of the transverse and line-of-sight distributions of galaxies. In a paper by Eric Aubourg and collaborators, BOSS astronomers measured the cosmic distance scale of galaxies in the "local" universe and of quasars in the distance universe with impressively small systematic errors—at less than the 1% level—when combined with cosmic microwave background constraints. Their cosmological analysis yields a measurement of the Hubble constant and of the matter density of the universe consistent with a "flat" cold dark matter cosmology with a cosmological constant (see below). Cosmological models including curvature, evolving dark energy, or massive neutrinos are not completely ruled out but are less supported by the data than before...***Read More***...



*Distribution of galaxies and quasars in a slice of BOSS out to a redshift of 3, or 11 billion years in the past. (Courtesy: SDSS-III.)*