Name Emma Date ________ Period ____

Article Research and Analysis Part 2

1. Find a research article (post 2005) that describes an application, extension, or development of BEC. **Attach the first 2 or 3 pages of the article.**

2. Write a properly formatted APA bibliography for the research article.

A room temperature Bose Einstein Condensate (BEC). (n.d.) Retrieved February 15, 2016, from http://eecs.umich.edu/eecs/about/articles/2013/a-room-temp-b-e-c.html

3. Determine the reliability of the article by evaluating each CARS category to establish reliability.

Category	**State whether article is C, A, R, or S and explain why by providing a statement(s), name(s), or detail(s) from the article (or lack thereof) that supports your statement.** Use four different highlighters showing the part of the article that is credible in one color, accurate in a second color, reasonable in a third color and support in the fourth color. Color the letters below that correspond to the highlighted article.
C	The author, Pallab Bhattacharya has a Ph.D. in electrical engineering and computer science. He and his team are from the University of Michigan, which is the #1 Public Research University in the US (National Science Foundation)
A	The article was written in 2013, so it is up to date with the latest understanding of BEC. The experiment performed has an entire seperate paper about it, but in the article it has several diagrams, further depicting how the experiment went.
R	The article does not use words such as "never" or "always". Instead, it uses words such as, "could" and "hopefully." They also make it clear that the data found are from the Prof. and his team, and their views don't represent the entire science community.
S	Their main points come from their experiment, demonstrating BEC at room temp. Their fundamental ideas are backed up by the 1995 discovery of BEC at absolute zero.

4. Overall, is the information in this article reliable? Explain your answer.

Yes, because it is written by a well educated professor from a prestigous university, and it's ideas are supported by the experiment the team conducted.

5. Compare statements from your original article with statements from your research article and explain how the properties of BEC allowed the new application/extension.

Write 2 or 3 key statements from the **original article** that describe the properties of BEC necessary for the application described in your research article.	Write 2 or 3 key statements from the **research article** that show how the application in your research article is connected to the property described. *Make sure all key statements are highlighted within the research article.*
• Originally BEC was discovered at absolute zero using lasers, evaporative cooling and magnetic trapping to cool down rubidium atoms. • BEC could lead to more powerful laser devices that use beams of atoms, and to drive chemical reactions. • When atoms reach absolute zero, they form one super structure that behaves like a wave. When gas reaches absolute zero it forms the BEC.	• Prof. Bhattacharya and his team performed an experiment using nanowire to reach BEC at room temp. It involved putting the wire in a highly reflective bowl to produce polaritons and allow evaporative cooling to take place. • With discovering BEC at room temp., BEC becomes a coherent state of matter, so it is possible that the light emitted can be used for sensitive instrumentation and other measurements. • BEC is a group of boson (photons) particles that are different than electrons, and exist in a single quantum state. Prof. Bhattacharya has discovered BEC at room temp.

6. Explain whether the discovery of BEC should be considered a significant scientific discovery. Include examples from your research article. It should, because it is a new form of matter. It consists of photons, and are entirely different than electrons. Currently it can be used to further understand quantum phenomenons. It helps to understand superconductivity, for example in their lab they had photons pulsing through the nanowire. It will also help with very precise measurements. It could also lead to invisibility cloaks and quantum computers.

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Scientific Milestone: A room temperature Bose-Einstein condensate

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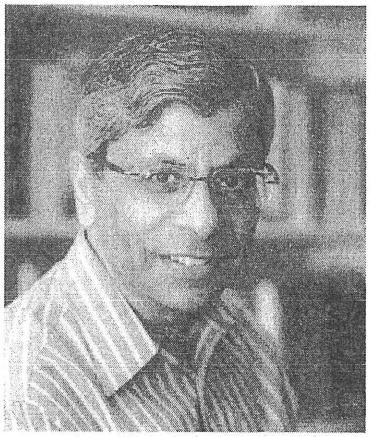


Pallab Bhattacharya, Charles M. Vest Distinguished University Professor

Prof. Pallab Bhattacharya and a team of researchers have created and directly observed what they believe to be a near-equilibrium room temperature Bose-Einstein condensate (BEC). A BEC is an unusual state of matter in which a group of boson particles can exist in a single quantum state, giving scientists the rare opportunity to directly observe novel quantum phenomena. A boson is a fundamental particle in nature having properties distinctly different from electrons. Photons are also bosons.

Though theorized by Satyendra Bose and Albert Einstein in the mid 1920's, the first BEC was observed in 1995, and it required cooling rubidium atoms to temperatures close to absolute zero. A combination of laser cooling of the atoms, magnetic trapping, and further evaporative cooling was required to reach this temperature.

Prof. Bhattacharya and his group recently demonstrated that using quasi-particles called polaritons, which are bosons, it is possible to observe a BEC at room temperature.

A paper on the research is published in *Proceedings of the National Academy of Sciences*.

"Our experiment was done with a very thin wire – a nanowire – made of aluminum (Al), gallium (Ga) and nitrogen (N)," explained Prof. Bhattacharya. "Thus it is an alloy (AlGaN) nanowire, but with varying amounts of Al and Ga along its length to form a trap in a small section of the nanowire where there was no aluminum.

The researchers buried the nanowire in a bowl-shaped, reflective device called a dielectric resonant cavity. Then they shined light on the nanowire to excite particles where there was a high content of aluminum. The light reflecting in the cavity coupled with exciton particles in the nanowire (an exciton is an electron bound to a "hole," or place where an electron used to be).

Additional Info

Researchers:

Pallab Bhattacharya, Charles M. Vest Distinguished University Professor

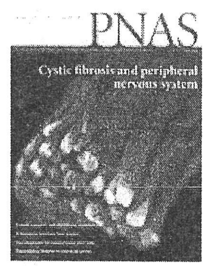
Ayan Das (PhD EE 2012), now at Intel, Portland, OR

Dr. Junseok Heo (PhD EE 2011), postdoctoral research fellow

Animesh Banerjee, graduate student

Wei Guo, former postdoctoral research fellow now at Rochester Inst. of Tech.

Original Publication:



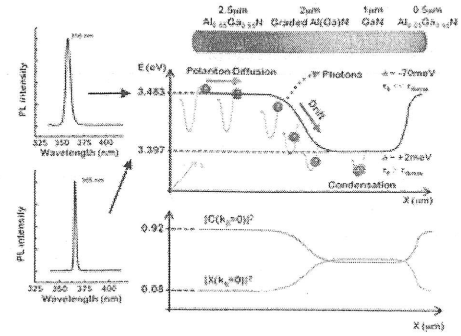
Polariton Bose–Einstein condensate at room temperature in an Al(Ga)N nanowire–dielectric microcavity with a spatial potential trap, by Ayan Das, Pallab Bhattacharya, Junseok Heo, Animesh Banerjee, and Wei Guo, *Proceedings of the National Academy of Sciences*, February 19, 2013, vol. 110 no. 8.

C-PHOM

NSF Center for Photonic and Multiscale Nanomaterials (C-PHOM)

In the News

Ars Technica - Bose-Einstein condensate



Schematic of the Al(Ga)N nanowire showing the variation of the exciton energy as a function of position. See the published online paper for more information and complete figures.

Together the photons and excitons produced polaritons. These polaritons then diffused and drifted towards the trap in the nanowire.

"As the polaritons moved along the nanowire, the ones with the highest energy exited the cavity as light, enabling evaporative cooling and ensuring that the coldest polaritons reached the bottom of the trap to form a near-equilibrium BEC at room temperature," Bhattacharya continued.

Prof. Bhattacharya believes this to be a significant scientific achievement that will allow other scientists and researchers to more easily pursue as-yet unknown avenues of research afforded by room temperature BEC's. Specifically, he states that because the polariton BEC is a coherent state of matter, it is possible that the light emitted can one day be controlled and used for sensitive instrumentation and measurements.

C-PHOM

This research was conducted as part of the NSF Center for Photonic and Multicscale Nanomaterials (C-PHOM), directed by Prof. Ted Norris. Prof. Bhattacharya leads one of the two primary thrusts, called the Wide Bandgap Nanostructured Materials for Quantum Light Emitters. C-PHOM will develop high-tech materials that manipulate light in new ways. The research could enable advances such as invisibility cloaks, nanoscale lasers, high-efficiency lighting, and quantum computers.

Catharine June (cmsj@umich.edu)
Communications Coordinator for ECE

Original article by Nicole Casal Moore, College of Engineering

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created at room temperature (February 6, 2013)

Reddit - [discussion on the significance of a room temperature BEC]