Spotlight

Be Flexible! Be Persistent! Be Patient!

By: Albert C. Biondo

Alumnus Albert C. Biondo gives career lessons for young physicists as he tells us of his not-so-typical journey to the field of mathematical modeling of sonar and underwater sound

My journey as a scientist actually began at UMCP's "little brother", UMBC, in 1972. I entered UMBC with the intent of transferring to the College Park campus to enroll in the latter's nuclear engineering program. (I had always been fascinated by the atom and atomic energy.) UMBC, at the time only 6 years old, offered a Physics program, so I entered it, all the while thinking I would transfer in 2 years. Wouldn't you know it - in 1972, a moratorium was placed on Nuclear Power Plant construction and it seemed that my "career" aspirations would have to change. Luckily, I was enjoying Physics (really - I was!), so I decided to stick with it, concentrating primarily on nuclear physics (Lesson No. 1: Be flexible!).

My experiences at UMBC were terrific, but my post-graduation experiences were a little unsettling. Translation: I couldn't get a "technical" job with just a bachelor's degree in Physics - believe me, I tried for over 8 months (Lesson No. 2 : Be persistent!). I began to wonder - what exactly could I do with a Physics degree? As it turns out, I had a "minor" in computer science (wonderfully prepared and taught by Dr. David Milgram of UMCP as a "visiting" professor" at UMBC - he literally would drive up from College Park to teach the classes!) which helped "expand" my options. Ultimately I landed a job at the Johns Hopkins University - Applied Physics Laboratory (APL for short) almost a year after I graduated.

Having been born and raised in Baltimore, I was quite familiar with Johns Hopkins as a medical institution, but I knew very little about this facility in Howard County, MD just south of Columbia. It seems that the lab had been around since WWII days, doing R&D for the DOD, NASA, and some private concerns - and occasionally doing some joint projects with the medical school. I began working in the Acoustics group in the Submarine Technology Department at APL, involved in designing, prototyping, and

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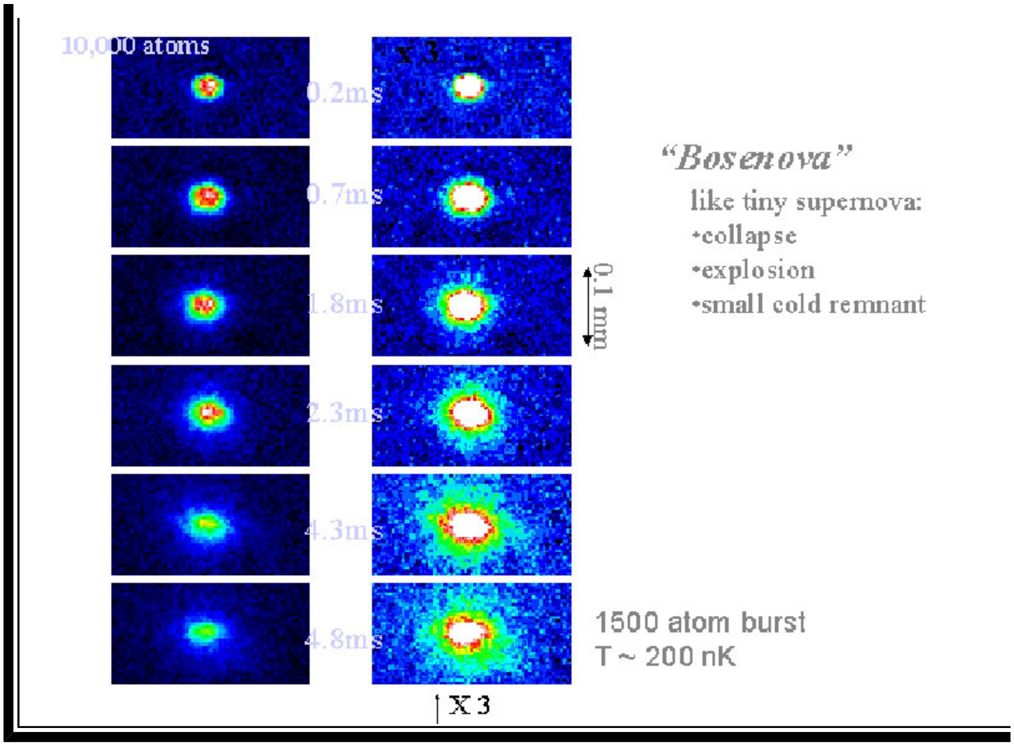
Cosmology in a Cold Teacup

By Professor Bei-Lok Hu

You are probably familiar with the large scale NASA experiments like COBE and WMAI looking into the relatively late cosmos. But do you know that certain table-top experime involving cold atoms in Bose-Einstein condensates (BEC) may be used to test out som basic quantum processes in the very early universe?

Prof. Calzetta of the University of Buenos Aires (a postdoc in our gravitation theory grou in the mid-80's) and Prof. Bei-Lok Hu of our department recently made such a novel suggestion. Their theory explains that the salient features of an experiment carried out Donley et al [Nature 412, 295 (2001)] at NIST-Boulder in 2001 on the controlled collaps of a BEC condensate (`Bosenova'), such as the emission of atoms in bursts and jets, a the result of quantum fluctuations parametrically amplified by the dynamics of the condensate. Quantum cosmologist believed this process had happened around the Planck time, 10^{-43} seconds from the Big Bang. Vacuum fluctuations are excited in a similar way by the enormous energy in the dynamics of spacetime, producing particle pairs which made up the matter content of the universe.



The Bosenova experiment also illustrates another important cosmological process, structure formation during a rapid quench. Galaxies were formed very late in the history the universe, even later than the COBE or WMAP detectable eras. But their seeds cam from quantum fluctuations of the scalar field which drove the universe into inflationary expansion at a very early time, 10^{-35} seconds from the Big Bang for a grand-unification (GUT) epoch phase transition. It is easy to see that an inflationary expansioi the time-reverse of a rapid quench in the BEC collapse. But how exactly does a primorc quantum seed grow into today's massive galaxies?

There is a constant competition between two rates, the physical frequency of a perturbation mode describing the density contrast, and the expansion rate of the univer the Hubble constant at that time. The modes whose physical frequencies are higher thi the Hubble constant are ``inside the horizon'', they oscillate. Conversely, the modes are ``outside the horizon'', they are `frozen' and amplified, a process analogous to the grow of fluctuations during spinodal decomposition. These modes which left the inflation horizon reenter the Robertson-Walker horizon during the radiation and matter dominate eras, giving rise to acoustic oscillations which grew into structures.

In the BEC collapse problem, the role of the ``Hubble'' constant is played by the inverse growth (exponential) rate of the most unstable mode of the condensate, which is determined by the instantaneous number of particles in the condensate. As these mode change from exponential growth to oscillatory behavior, they are ``thawed''. Perceived i particles being created from the condensate, they form the jets and bursts observed in Bosenova experiment.

This remarkable discovery by Calzetta and Hu of using BEC collapse to test out quantu processes in the early universe should open up a new venue for doing `laboratory cosmology'.

You can read more about this in http://www.lanl.gov/arXiv:condmat/0207289

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testing various advanced sonar systems for the US Navy. I still was wondering when I would use all of the Physics stuff I had learned.

Then it all seemed to click - my Physics and Mathematics background (particularly quantum mechanics) enabled me to dive into (no pun intended!) the realm of underwater acoustic propagation and noise modeling. I had no formal education in acoustics (beyond being able to set up my stereo at home - I was a Zeppelin fan then) - but my background enabled me to accept the challenge of a new discipline (Lesson No. 3: Keep an open mind!).

I immediately took advantage of APL's excellent continuing education program - I enrolled at UMCP as a graduate student in Physics (finally - the connection to College Park!). However, being a part-time student and full-time employee was quite arduous. I got married in 1979 - to a UMCP alumnus with an MSEE - who was very supportive of my educational endeavors, but was anxious to see me finish (Lesson No. 4: Be patient! - thank goodness she was!). I finally received my MS in Physics in 1982 - hallelujiah!

The degree served me well at APL as I continued my efforts in mathematical modeling of sonar and underwater sound. However, I also had ample opportunities to perform experimental investigations of these phenomena and apply the results to the development of empirical models. I often would go to sea for 2-3 week "cruises", performing experiments in conjunction with other scientists from APL, as well as other university and government organizations. I really had entered into the area of oceanographic research (there's Lesson 1 again - be flexible!) and, although Jacques Cousteau I wasn't, I had many rewarding and enlightening experiences during my sea trips.

Well, I've been at this stuff now for about 25 years - I've traveled the world - mainly the seas, but you have to start and end on land somewhere - and I'm continually being challenged with new opportunities in mathematical modeling, simulation, and systems analysis. And, I really owe it all to Physics - the technical degree which opened the door to a world of technical challenges and opportunities that I would have never though of, let alone thought of being able to face.

The theoretical background I obtained from my Physics education enabled me to describe some very complicated physical processes in mathematical form, which in turn could be readily represented by computer codes. My experimental background - my undergraduate thesis project as well as the UMCP graduate laboratory course, among others - provided the discipline to plan, conduct, and analyze experiments on a much grander scale than in the laboratory - the oceans became my laboratory!

So, what can you do with a Physics degree - the sky's (or should I say the ocean's) the limit!