AUTHOR COMMENTARIES - 2010

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Andrew Becker

Featured Scientist Interview

In a recent analysis of Essential Science IndicatorsSM *data from Thomson Reuters, the work of Dr. Andrew Becker entered the top 1% in the field of Space Science with the highest citation count. His record in this field includes 63 papers cited a total of 2,428 times between January 1, 1999 and December 31, 2009.*

Dr. Becker is a Research Assistant Professor in the Department of Astronomy at the University of Washington. Below, he talks with ScienceWatch.com *about his highly cited work.*

SW: Would you tell us a bit about your educational background and research experiences?

My interests in Physics and Astronomy were piqued somewhat randomly around 7th-8th grade when I picked up a used book by someone I had occasionally seen on TV named Carl Sagan. The book was called *Contact* and dealt in a very fascinating way with the nature and pursuit of knowledge, framed by this awesome circumstance of being contacted by extraterrestrial intelligence.

The characters really resonated with me, so I naturally became curious about the subjects they pursued in the book, namely mathematics but also the interplay between science and religion on an intellectual level. I was recently honored to meet Jill Tartar, on whom the protagonist Ellie Arroway was based, this past year in Washington, DC.

Amusingly, at that time I was also interested in books by another person I recognized from TV, L. Ron Hubbard, although I did not venture far from his popular science fiction books. My life certainly might have turned out differently had I ventured into Scientology instead of the physical sciences!

I decided to major in physics in college after experiencing a very invigorating AP Physics course in high school. As an undergraduate, I followed the well-trodden path of searching for basic jobs to sustain myself, eventually starting work in the undergraduate labs resetting the frictionless track experiments after hours.

After demonstrating a general sense of responsibility, and having done relatively well on course work, I started working on a cosmic ray experiment with Dr. Jim Gaidos, learning about photomultiplier tubes and turning flat glass into mirrors in the basement tunnels of Purdue University, right next to their tandem accelerator. We also worked on repairing the local Cumberland Observatory, including basic upkeep such as removing families of dead spiders, metalworking on the observatory dome, the purchase of eyepieces, and eventually undertaking successful observations of the Shoemaker-Levy 9 impact with Jupiter.

Here, I learned the basics of measuring the brightness and positions of stars in astronomical images. I found I had an aptitude for the necessary computer programming, originating from my days programming our TRS-80 computer, when I saved my work on cassette tape and worked on modifying the game algorithms to allow me to win. This programming background, along with the typing class my Mom made me take in high school, are two of the core foundations that have since allowed me to operate effectively in my field.

I moved to Seattle for graduate school, impressed by the natural setting of the city and the overall kindness of the students and department. The day I walked in the door I was offered a summer job working on one of the first large-scale time domain astronomical surveys, the MACHO microlensing project, coordinating global follow-up of events we had found.

"Because of advances in hardware, software, and information technology the next decade of astronomy promises a deluge of information."

It was here that I learned about writing general solutions to problems; your algorithms need to be robust if they are being applied to multiple data sets, each with its different kinks and wrinkles. I learned many of the benefits and complications of working within a large collaboration. Some of the team meetings were intense, even tearful, but learning the dynamics of discourse in large scientific groups has helped me to feel comfortable in the many collaborations I have joined since.

The needle-in-a-haystack nature of the project also required that I start to come to grips with some of the difficulties faced by astronomers today: anomaly detection in huge datasets, classification of events, coordinating global resources to follow-up events, and uses of advanced fitting techniques to compare models to data.

My first post-doctoral position was at Bell Laboratories, the legendary research institute where the transistor was developed, the C programming language and UNIX were written, and where the cosmic microwave background was accidentally discovered by laboratory scientists, ushering in a new age of experimental cosmology. While here I came to appreciate the benefits of having the intellectual freedom to pursue what interests you, and to be grateful for having the opportunity to do so myself.

The folks at our lunch table seemed to compete with each other to come up with the most extraordinary ideas for patents, such as using voltage spikes on undersea cables as early warning signs of tsunamis. I was somewhat embarrassed by the narrowness of my knowledge in only one area of the physical sciences; it was extraordinarily humbling.

It was here that I started to develop generalized variability detection code that used the simple premise that anything left in the *difference* between two images represents something that has varied in brightness or position. This software has since been made exceedingly robust by being applied to various time domain searches for distant supernovae, dark matter microlensing, Solar System asteroids, and to other generalized surveys measuring the distribution of the matter in the Universe.

This software became the catalyst for my involvement in the many astronomical collaborations that have led to my apparently prodigious citation record: the MACHO project, Microlensing Planet Search, Deep Lens Survey, ESSENCE survey, SuperMACHO survey, SDSS-II Supernova Survey, and Large Synoptic Survey Telescope (LSST) Collaboration.

I have since returned to and am now research faculty at the University of Washington in Seattle, where we are busy designing the next generation of optical astronomical time-domain surveys, the Large Synoptic Survey Telescope (LSST).

It's clear from reading the above I have been given many opportunities to succeed. I try and afford these opportunities to other young students through my involvement with various outreach programs, including the University of Washington's Pre-Major in Astronomy Program (Pre-MAP) and through the National Science Foundation's Faculty and Student Teams (FaST) program.

What would you say is the main focus of your research?

The vast majority of my research involves searching for time-variable phenomena in large astronomical data streams. This variability may originate from objects relatively close to home, such as moving asteroids orbiting our own Sun, or may be pulses of light that come from exploding stars in the distant Universe. The intent is to build a common platform that can measure and distinguish between these different classes of phenomena.

This involves addressing many difficult problems along the entire path from telescope to knowledge inference: data acquisition and storage, data reduction and mining techniques, designing statistical models of the data, and drawing conclusions from comparison of these models to the data. It also requires large collaborations of smart and competent scientists, all of whom have contributed greatly to my publication record, and whom I must thank for being recognized here.

Your most-cited paper, and several other of your highly cited papers, deals with the MACHO project. Would you talk a little about this aspect of your work?

The MACHO project was one of the first large-scale, real-time, optical astronomical time-domain surveys. We were searching for (literally) one-in-a-million stellar brightenings caused by gravitational lenses along our line of sight to background stars.

We had to study dense stellar fields, such as towards the Galactic center, to have any chance of seeing even one of these events. We also had to marshal resources to study these events once they were found.

In many ways it set the stage for my work today, which is the application of these principles on a much larger scale. I also met many of my current collaborators from working on MACHO. It was a very successful project in a variety of ways, and was

ADDITIONAL INFORMATION WITH IMAGES ABOUT ANDREW BECKER AND TEAM

The Pre-Major in Astronomy Program (Pre-MAP)

NSF Faculty and Student Teams Program (FaST)

American Astronomical Society

Newsletter (July/August 2009).

a great opportunity for a young graduate student.

The ESSENCE Supernova Survey also turns up quite a bit in your highly cited papers. Would you talk about this project and your involvement in it?

At the time of ESSENCE's inception, the High-Z and Supernova Cosmology Project collaborations had recently announced the first detection of "dark energy" (Riess *et al.* 1998; Perlmutter *et al.* 1999), a mysterious component of the Universe that is causing its expansion to accelerate.

In these surveys, time-variable supernovae were used as bright beacons to probe the expansion history of the distant Universe, a groundbreaking task that will almost certainly lead to the Nobel Prize for members of those teams.

We had recently started a successor to MACHO called (naturally) SuperMACHO, and I was working in Chile building an automated image subtraction pipeline with my invaluable collaborator Armin Rest.

While we were writing the code, the project's principal investigators were working on a parallel idea: we would use the same telescope and same software in a targeted search for supernova events instead of microlensing events! It was a challenge to make our software robust enough to operate in both regimes, but inevitably made the pipeline that much more valuable.

So the ESSENCE project is a nifty example of the notion that all problems are interesting and many of their solutions are interconnected. If you can make that connection, intellectually and programmatically, it can lead to new collaborative efforts.

Of all the projects on which you have worked, do you have a particular favorite?

My favorite era was from 2000 to 2003, when I was spending many months down in Chile working on the Deep Lens Survey, SuperMACHO Microlensing survey, and ESSENCE Supernova survey. This was the time of my post-doc at Bell Labs, and while I'm not sure they were appreciative of all the time I spent in South America, it did give me the intellectual freedom to get something very important done—to start facing some of the challenges that will come to define the upcoming decade in time-domain astronomy.

In some sense this is exactly what is supposed to happen during your post-doctoral tenure, before you become overwhelmed with the academic and teaching responsibilities of being a professor. Much of the software written during this era in still in use today, some of it even serving as a reference for the next generation of astronomical applications.

Are there any projects you have forthcoming that you are free to discuss?

The most visible is the Large Synoptic Survey Telescope. This survey promises to acquire, archive, and serve to the general public more data than has been taken in the prior cumulative history of Astronomy! It will survey the entire visible sky every three nights, continuously for 10 years. Most importantly, we will be releasing these data to the general public (amateurs as well as professional astronomers) in truly real-time.

This is the democratization of science, simultaneously enabling research by professors at universities with limited resources, as well as by faculty at universities with access to the largest telescopes on the planet. The results of this "cosmic cinematography" will also serve as a valuable teaching resource for education and public outreach.

From a technical point of view, the data challenges here are enormous. We need to mine these data in real-time for outstanding events that deserve additional and immediate study. To do this requires we recognize and classify the more prosaic types of variability that may masquerade as these rare phenomena.

To maintain the community's trust we need to do this with an appropriately low false-alarm rate. All the aspects of this problem require that I broaden my own knowledge and understanding of statistical modeling, classification, and data-mining techniques.

"The vast majority of my research involves searching for time-variable phenomena in large astronomical data streams."

In what directions do you see the field of astronomical surveys going in the next decade?

Because of advances in hardware, software, and information technology the next decade of astronomy promises a deluge of information. Much of the science will not get done at the telescope, but instead by an astronomer sitting in front of a computer and executing queries on a massive database. This requires an entirely different skill set than has been needed to excel in astronomy in the past, and thus it's imperative that we start to teach these skills to graduate students as soon as possible.

However, optical astronomical surveys such as LSST are only one facet of the next decade of astronomy. Due to new technologies we are also probing the Universe in fundamentally new regimes, from gravity waves to neutrinos.

We are also slowly but surely developing the technologies needed to search for the signatures of planets around other stars, and for ascertaining whether or not they may harbor life. This includes direct imaging techniques, methods to infer the atmospheric properties of the planet, and even searches such as SETI looking for signatures of technology coming from these distant planets.

The challenge in all these cases is to find the needle in the haystack, that rare event that changes our understanding of the field, but whose discovery is enabled by the accumulation of massive amounts of data. Acquiring and understanding these data pose the largest challenges for our field in the next decade.

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Andrew Becker's current most-cited paper in *Essential Science Indicators*, with 322 cites:

Alcock C, *et al*., "The MACHO project: Microlensing results from 5.7 years of Large Magellanic Cloud observations," *Astrophys. J.* 542(1): 281-307, Part 1, 10 October 2000. Source: *Essential Science Indicators* from Thomson Reuters.

Additional information:

- Andrew Becker was a New Entrant in February 2010.
- The Pre-Major in Astronomy Program (Pre-MAP)
- NSF Faculty and Student Teams Program (FaST)
- American Astronomical Society Newsletter (July/August 2009).

KEYWORDS: ASTRONOMICAL SURVEYS, MACHO PROJECT, MICROLENSING, VARIABILITY DETECTION CODE, MICROLENSING PLANET SEARCH, DEEP LENS SURVEY, ESSENCE SURVEY, SUPERMACHO SURVEY, SDSS-II SUPERNOVA SURVEY, LARGE SYNOPTIC SURVEY TELESCOPE (LSST), TIME-VARIABLE PHENOMENA, LARGE ASTRONOMICAL DATA STREAMS, COLLABORATIONS, DATA MINING.

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