

TECHNOLOGY OBSERVER

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A LETTER FROM THE ALBERT DORMAN HONORS COLLEGE...

Letter from the Dean

Dear Reader,

Welcome to the eleventh edition of the *Technology Observer*, a publication founded, managed, researched, written, and designed by Albert Dorman Honors College students in order to report on emerging technologies. Matthew Deek, Editor and his fellow authors researched the emerging technologies for the study of space. As I read these well researched, well written articles, I was reminded of a quote from astrophysicist John N. Bahcall about the Hubble Space Telescope:

We often frame our understanding of what the space telescope will do in terms of what we expect to find, and actually it would be terribly anticlimactic if in fact we find what we expect to find...The most important discoveries will provide answers to questions that we do not yet know how to ask and will concern objects that we have not yet imagined.

In this issue, Andrew Deek, a freshman Honors Scholar imagines the prospect of some forms of life different from what we know in other parts of the universe by researching the multidisciplinary science of astrobiology. David Thompson and Peter Besada are both “looking up at the sky... for the birth of a star...to find an Earth-like planet.” David recounts the study of stars through photography, spectroscopy and SIRTf. Peter focuses on the detection of extrasolar planets and the emerging NASA technology of “Formation Flying” and the 2013 scheduled launch of the James Webb Space Telescope. Bushra Hossain and Matthew Deek review the work of NASA’s three active observatories that are in orbit, Chandra X-Ray Observatory, Rossi X-Ray Timing Explorer and the Hubble Telescope, and conclude similar to Bahcall that “...many questions about the universe have yet to be answered, but there are also many more questions that have yet to be asked.” Declan Tonna introduces us to “SpaceX” funded through NASA’s COTS program to “...spark outside interest in space exploration.” SpaceX is developing rockets and capsules for commercial use, possibly to replace NASA space shuttles.

Two of the Honors Scholars wrote about a couple of NJIT’s outstanding faculty and their respective research. While many know about NJIT’s Big Bear Solar Observatory, fewer appear to know about the university’s operation of the Owens Valley Solar Array, led by Dale E. Gary, Distinguished Professor and nationally recognized astronomer. Our author, Mousa Hamad, briefly cites Dr. Gary’s important work on the effect of the Sun, magnetic field disturbances and our daily life. Bishoy Hanna, appeared to take a different tack, and wrote about Associate Professor of Management, Katia Passerini. Dr. Passerini’s research focuses are knowledge-creation factors and learning systems for business development, however, both are also clearly integral to the continued study of space.

I thank our Editor, the authors and their advisor, Dr. Paul Dine, and invite you to join us in this exploration of knowledge about space.

Most sincerely,
Joel Bloom



About New Jersey Institute of Technology

THE EDGE IN KNOWLEDGE

New Jersey Institute of Technology is a public research university enrolling over 9,400 bachelors, masters, and doctoral students in 96 degree programs through its six colleges: Newark College of Engineering, The College of Architecture and Design, College of Science and Liberal Arts, School of Management, College of Computing Sciences, and the Albert Dorman Honors College. A top-tier research university, NJIT houses laboratories in 48 key areas and 20 state-of-the-art multidisciplinary centers. Research initiatives include manufacturing, microelectronics, multimedia, mathematical sciences, transportation, computer science, solar astrophysics, environmental engineering and science, and architecture and building science.

About the Albert Dorman Honors College

ENGAGING THE FUTURE

The vision of the Albert Dorman Honors College is the engagement of the brightest students with the best faculty, original research, and practice-oriented projects. The context of this engagement is inquiry-based learning, a computer-intense campus, and urban setting, diverse population, global relationships, and an environment that is erudite and transformational.

The Albert Dorman Honors College currently enrolls over 620 students, with average SAT scores above 1300. Students are enrolled in honors courses, participate in leadership colloquia, partake in professional projects, and conduct research with faculty at various NJIT research centers. These scholars work closely with national and international businesses and industries, and participate locally in community activities. They are leaders on the NJIT campus, and future leaders in the science, engineering, mathematics, and technology professions.

For more information :: honors.njit.edu

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...THE TECHNOLOGY OBSERVER TEAM

A Letter From The Editor

Why is it that we are so preoccupied with who else might be sharing our universe? Our planet is just a tiny dot in what we call the universe. Might this explain our constant search for other beings and new habitats elsewhere?

Space exploration has gone on for as long as human activities have been documented on our planet. In ancient times, civilizations studied the sun and the stars for years in order to create their calendars, tell time, and determine direction coordinates. In modern times, space exploration has mirrored the geopolitical, military, and economic conflicts between countries that have engaged in it. Tourism now seems to be another motivation for exploring the universe.

We are privileged to be living during an exciting period for space exploration. Space missions, manned and unmanned, seem to be making discoveries almost on a daily basis. Water, essential for life as we know it, has already been found on Mars, albeit in ice form. Today, space technology is at its best. Telescopes on earth as well as on space stations have captured amazing pictures and allowed for gathering data that are challenging our most fundamental understanding of the universe.

On behalf of the excellent writers and dedicated staff of the *Technology Observer* Magazine, it is an honor to present to our readers the eleventh edition of the Observer.

Sincerely,

Matthew Pierre Deek
Editor-in-Chief

A TRULY STELLAR LIFECYCLE

David Thompson

Look up at a clear night sky and they are everywhere—millions of stars shine as tiny white dots of light and stand out against the otherwise dark background. Since ancient times, people across the globe have admired, studied, and even worshipped stars. After thousands of years of learning about stars and having gained a vast understanding about their structure and behavior, what can humanity do to boost and heighten its ability to pursue further knowledge about the stars?

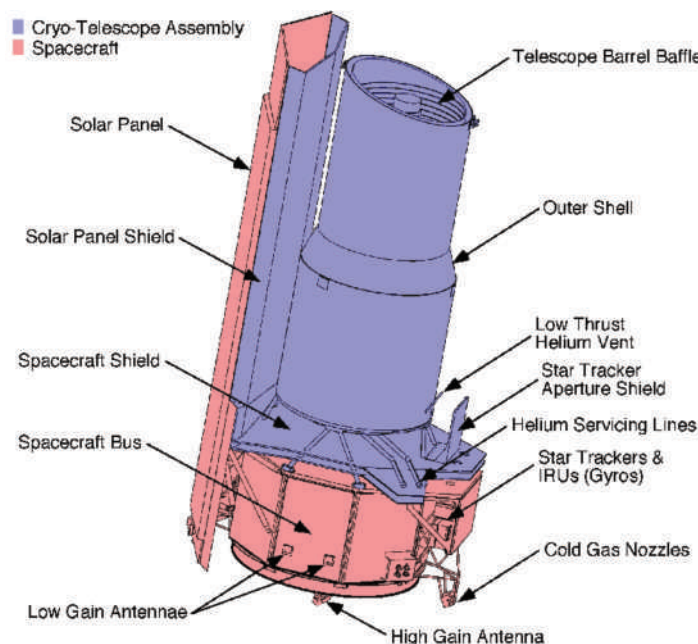
The star we are most familiar with is the Sun. As the brightest object visible from Earth and the ultimate source of our planet's energy [6], the Sun does have an attractive façade. It is believed that astronomy began in ancient Babylon with the Chaldeans around 600 BC [16, 17]. While originally many people believed that the Sun was a unique star of the solar system, after careful observation early astronomers suggested that the dots visible in the night sky named stars shared many similarities with the Sun. Surprisingly, over the years astronomers discovered not only that they were similar, but that the Sun is nearly identical to a huge number of stars in terms of its life cycle, its close-up appearance, its behavior, and its composition.

A star begins its life when a gaseous nebula composed primarily of hydrogen begins to bundle itself together around a certain point, for some yet undiscovered reasons. After this happens, the protostar gains its first meaningful amount of gravity, and, as a result, the surrounding gas joins itself to-

gether with the original bundle in a process known as accretion [1]. The protostar then gains considerable bulk, and must reach and maintain a high equilibrium temperature to facilitate the nuclear fusion of hydrogen into helium, a characteristic of essentially all stars [1, 2, 3, 4]. If the protostar is incapable of doing this, it becomes a brown dwarf; if it succeeds, a new star is born!

Today, the primary form of studying stars is through photography. Astronomers and photographers take pictures of the stars and then analyze them using either the classical method of film photography or Charged Coupled Devices more commonly referred to as CCD chips. CCD chips are employed with a computer system to generate an image within seconds that bears a greater likeness to the star than

conventional film [18]. These large, detailed pictures are useful for astronomers, as they allow for the observation of any changes to stars that occur over time, while also facilitating communication between scientists by eliminating ambiguity. With photos, scientists can simply point to what catches their attention instead of trying to direct others on how to find the location in the broad expanse of the night sky. As modern photography develops through the advent of computers, many new means of photography are on the horizon and it is thus likely that film photography will soon become obsolete.



Telescope used to view stars in outer space [1]

Second only to photography [7], spectroscopy grants scientists otherwise unobtainable insight into the composition of stars. Spectrophotometers separate the light that a source emits and analyzes it. A Cornell University researcher notes that spectrometers “are a lot like really good prisms [because] they take light from some object and separate it into its colors” [5]. Depending on the constituent colors that astronomers detect, they can identify what elements produced the observed light by comparing the color to each element’s respective “fingerprint.” Almost all stars are predominantly composed of hydrogen and helium, but knowing what else stars are composed of enables astronomers to predict how a star burns, how it affects any orbiting planets, and how long that star has to live.

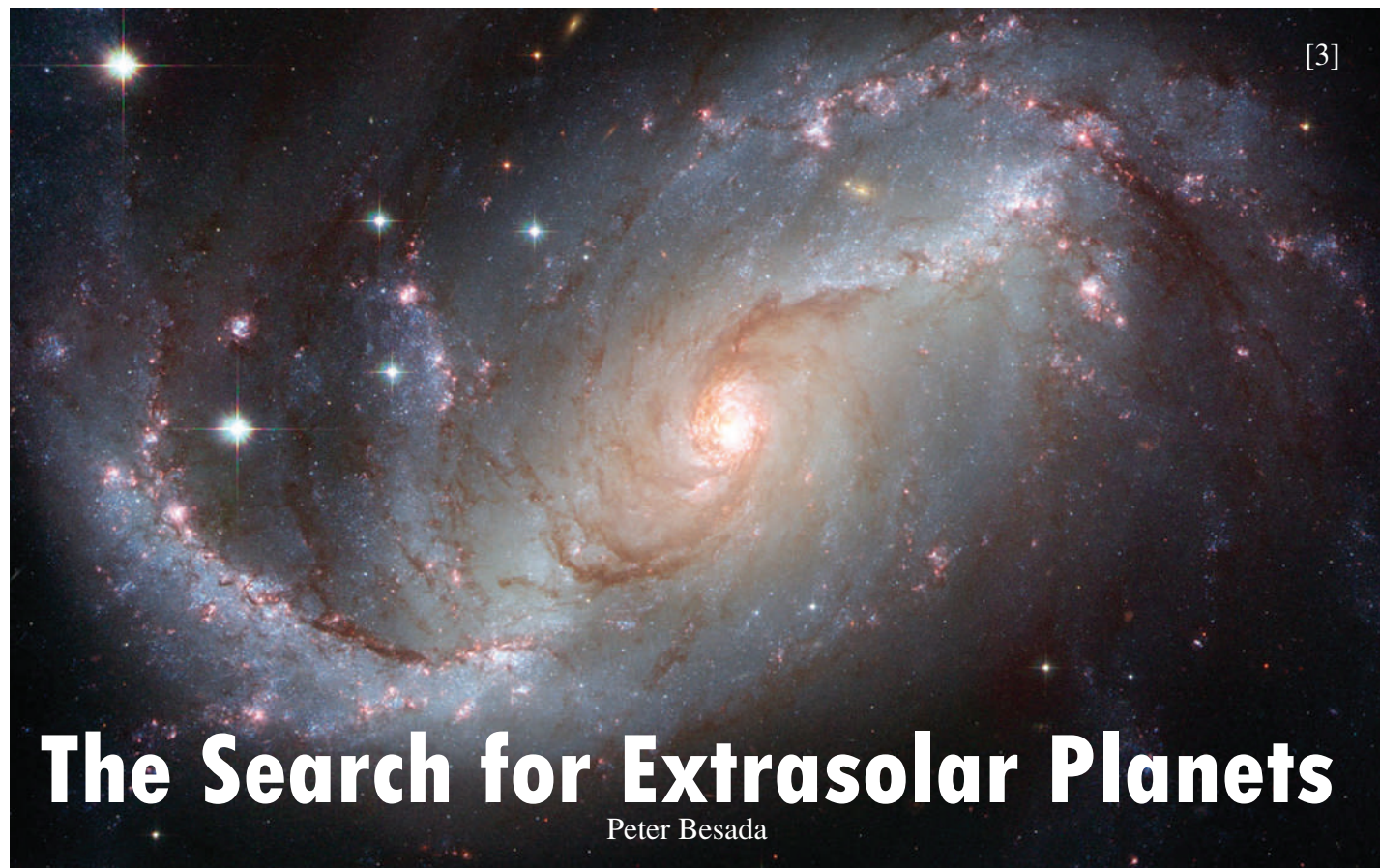
In order to measure the distance of stars, scientists view stars from a given observatory. Since an angle is necessary for depth perception, it is only possible to measure distances if observation occurs from two different points. Nineteenth century scientists used to accomplish this by observing from two different observatories and noting the angle formed between them and the star. However, this approach does not take account of the curvature of the Earth, so contemporary astronomers make observations from the same observatory but at opposite positions of the Earth’s orbit. Though usually negligible, the Earth’s curvature is significant here because the angles formed are tiny at less than $1/3600$ of a degree and very sensitive to error [9]. These data are then used to find the star’s parallax in arc-seconds, which can be converted to light years. For stars beyond some 300 light years or more, the star’s cluster parallax is instead calculated by considering the angle between observing locations and the relative velocity of the galaxy of such a star or cluster of stars to which it belongs.

Of course, some stars prove elusive and must have their distances calculated based on their brightness. Much like a person estimates the distances of cars while driving at night based on the brightness of headlights and taillights, an astronomer can estimate the distance of a star based on its true brightness by using the Hertzsprung-Russell (HR) Diagram, which was developed in 1914 [9]. If a star ends its life by exploding in what is called a supernova, it gives off an immense amount of light. This enables scientists to recognize stars undergoing the supernova phase that are up to 10 billion light years away [8].

In order to obtain the data essential to their calculations, astronomers still utilize telescopes. One of the more advanced telescopic technologies is that of SIRTf, or the Space Infrared Telescope Facility. Launched in 2003, SIRTf is a specialized telescope designed to operate outside of Earth’s atmosphere, as the presence of atmosphere obscures results and hinders the ability of telescopes to probe long distances. The great benefit of SIRTf is that it is designed to operate at just a few degrees above absolute zero and that it can see cold, dust-enshrouded objects that would otherwise be impossible to perceive with current technology [10, 12]. Similarly, since gravity waves fluctuate when a star is engaged in an activity such as a collision or a supernova, the Laser Interferometer Gravitational-wave Observatory (LIGO) has undertaken a comparable task in which it collects information on enigmatic stellar events by monitoring gravity waves [11].

Over the years, technology has allowed astronomers to learn the similarities between the Sun and the stars, formulate the life cycle of stars, predict the behavior of stars, and discover their composition. Had it not been for technologies such as the telescope, the spectrophotometer, and rockets to make observation easier, humankind may never have had the luxury of indulging its curiosity about these magnificent and distant wonders in space.





The Search for Extrasolar Planets

Peter Besada

Man has been looking up at the heavens since the beginning of time asking the same questions we are asking ourselves today: Are we alone in the universe? The ultimate goal for astrophysicists is to find an Earth-like planet. The ancient Greeks speculated that there possibly might be other solar systems capable of harboring life. The ability to locate and observe planets outside our solar system is a relatively new phenomenon and is due to the available technologies.

Planets located outside our solar system are referred to as extrasolar planets. The first extrasolar planet was not discovered until 1995. Didier Queloz and Michel Mayor located the star 51 Pegasi nearly 50 light-years away. The first ever discovered extrasolar was a Jupiter-like planet, possibly twice the mass of Jupiter. Several months later, Geoffrey W. Marcy of San Francisco State University and Paul Butler of the University of California at Berkeley confirmed this discovery and identified two more of their own [3, 4, 6]. This led to the discovery of

several dozen planets by the end of the 20th century. Unfortunately, many of the newly discovered planets offer remote possibilities of harboring life. Most of them are giant gas masses that orbit very closely to their stars [3, 6]. The sudden swell in discoveries of extrasolar planets can be attributed to the technological advances. Improvements in computers, sensors and measuring devices can better separate starlight into its component colors for analysis.

Stars are easy to locate. Just by looking up at the night sky, the human eye can detect thousands upon thousands of stars. Planets are an entirely different story. Extrasolar planets are far too tiny and dim because they only reflect the light from a star [2, 6]. These faint planets are located so closely to their neighboring star, it is nearly impossible to tell them apart. Because it is difficult to directly view the planet, several methods have been developed to locate and even take snapshots of these planets.

One such method is to compare the relative movement and position of a planet to a star. It is said

that a planet revolves around its star, implying the star is stationary. This is a misconception. In fact, both the planet and the star revolve around their combined center of mass. By measuring the velocity or changing position of the star, the planet's mass and orbit is revealed. Because the mass of the star is so much greater than that of the planet, the center of mass is located extremely close to the star making the star's orbit very small [6, 7]. As an astronomer observes a distant star the spectrum of starlight fluctuates. This phenomenon is known as the Doppler Shift. As a star moves nearer to the observer, the light waves from the star shift to the blue end of the spectrum. As it moves away from the observer, the light waves shift to the red end of the spectrum. This happens because as the star moves nearer, the waves are compressed giving it a higher frequency and then elongated as it moves away giving it a lower frequency. The larger the shift in the frequencies, the faster the star is moving, which makes it possible to deduce its speed. However, this is only true for movements that approach us and move away from us; the method does not reveal its velocity moving sideways [7].

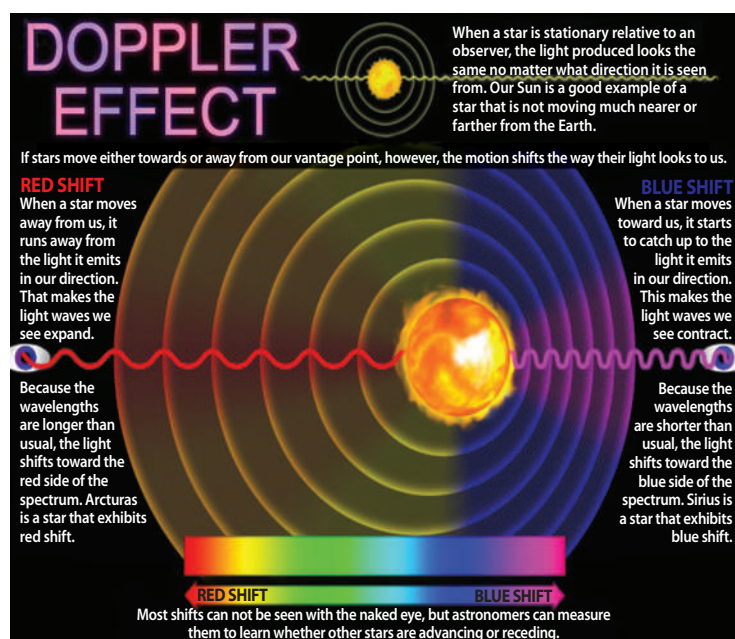
It is also possible to use astrometric measurements to calculate the displacement of the star in the sky. As the gravitational pull between the star and

planet affects the trajectory of the star, these small movements can be directly calculated. Consequently, the size and mass of the affected planet can be determined.

Gravitational microlensing is another method used to locate planets. It is derived from Albert Einstein's theory of general relativity. Light does not travel in a straight line, but bends when it passes through a space warped by the presence of a massive object such as a star. This force that bends space is known as gravity. When a planet passes between a star and our line of sight, the planet's gravity will bend and intensify the light from the star. This effect, gravitational microlensing, allows us to detect objects that do not emit light [6].

Another method used to detect extrasolar planets is known as optical interferometry. This method involves the use of several telescopes that work together to act as one, much larger telescope. The light from the different telescopes interact with each other in a way that cancels out the blinding glare of the star, making the orbiting planet visible. This technique has been used to observe the structure of distant galaxies for nearly half a century [6]. However, the technologies needed to apply this technique on a smaller scale have been only developed in recent decades with the advent of computers and state of the art light sensors [6].

In astronomy, one of the greatest challenges is not merely locating extrasolar planets, but actually being able to photograph them. A star can be between one million and ten billion times brighter than its orbiting planets. There are several techniques that are currently being developed to make extrasolar planet imaging a reality. The first method involves the use of a coronagraph, which was invented in 1930 by Bernard Lyot. The coronagraph was used to study the Sun by blocking the light coming from the solar disk. Essentially, it is like creating an artificial solar eclipse, making it possible to study the corona or atmosphere of the Sun. This is achieved by using a series of concentric rings that block out the light from the star without blocking out the planet. By using different shapes, the diffrac-



Schematic of the Doppler Effect [4]

tion of light can be controlled so that it is dimmer in some areas and brighter in others [1, 6].

The future of extrasolar planets is larger and brighter. Formation Flying is a critical element in NASA's search for Earthlike planets. There are plans to develop the technology needed to fly multiple spacecraft in such perfect harmony, that they become a single instrument, bigger and better than could be launched ready made from earth. The objective is to have five separate spacecraft work together to function as a single large telescope. It will be powerful enough to distinguish the faint light reflected off a planet and the much brighter stars it orbits. There are many advantages to flying multiple spacecraft rather than one large telescope. It is much easier to control several smaller telescopes with a certain level of accuracy rather than designing and controlling one large telescope. It also allows for easy repairs, changes and upgrades. Unfortunately, no technology currently exists that allows separate, unconnected spacecraft to function as if they were a single, solid structure. "The key is coordination and control" [6].

Even if scientists are able to locate an extrasolar planet, what does it mean for humanity? How will it benefit us? After all, surely astronomers are not just searching for planets. The ultimate goal of NASA is to find an Earth-like planet, one that can support life. By analyzing the atmosphere, temperature, mass, etc. of the planet, scientists can determine whether life can exist or if it is habitable for humans. The best place to look for an Earth-like planet is in the habitable zone. This is the region in the solar system where liquid water can exist. If the planet is located too close to the star, the water will turn to vapor; if it is too far the water will freeze. Both scenarios will make it unlikely that any forms of life exist there [6].

If a planet were to have large amounts of oxygen in its atmosphere, this would give it a high likelihood that life does exist. Here on Earth, oxygen is produced by the process of photosynthesis. However, the oxygen produced doesn't just stay there, it combines with other molecules. So if a large amount of oxygen was present, then there is a good chance that there is life replenishing this oxygen. As exciting as this may be, oxygen does not produce a spectrum that is detectable using infrared technolo-

gies, making it difficult to observe. However, ozone, which is made up of oxygen, can be observed. The detection of ozone can provide resounding evidence of the planet being habitable or even harboring life [6].

The future of planetary discoveries may not be so far away as we think. Currently in development, the James Webb Space Telescope is scheduled to launch in 2013. The telescope, 6.5 meters in diameter, is optimized to use infrared light. It will be positioned in an orbit nearly one million miles away from Earth. This is four times the distance from the Earth to the moon. The Webb will look deep into the distant universe, attempting to connect the Big Bang to our own galaxy. With its modern capabilities, the Webb will not only locate and analyze extrasolar planets; it will also help scientists understand how our solar system formed and evolved [5]. The European Space Agency is also currently working on Gaia. Gaia is designed to map our galaxy with extraordinary accuracy. It consists of two extremely sensitive telescopes mounted onto a single structure orbiting the sun at a distance nearly one million miles from Earth. Gaia will observe stars and will determine their position, velocity, and photometry. By the end of its life, Gaia will have observed and recorded data for about one billion stars, only one percent of the star population in the Milky Way galaxy [6].

Our ever advancing technologies make it possible to look deeper and more accurately into our universe. Since 1995, the rapid growth in the discoveries of exoplanets has been exponential with over 250 planets already discovered. With newer technologies, both those currently in development and those which are still in the conception stage, we are learning more about our surrounding galaxies and their solar systems. The future holds promise for our never ending search for life in the universe. Perhaps now, we are closer than ever to answering a most commonly asked question: Are we alone in the universe?

Deconstructing Science Fiction

Matthew Deek and Bushra Hossain



NJIT's Space Weather Lab Observatory [5]

Unanswered questions about space have plagued humankind for centuries. Inevitably, since the inquisitive nature of the human race continues to drive us to seek to learn ever more about how the universe functions and continues to evolve. Instruments and observatories for the purpose of studying space have persisted now for more than 2000 years. Findings of the earliest observatories may have been lost, but some of the actual sites of space observation have survived over time. Stonehenge – believed to have been erected around 2500 BCE – is known for being one of the earliest sites built to observe cosmological phenomena like the summer and winter solstices. Like Stonehenge, most of the earliest observatories were fairly simple. Space was first observed only with the naked eye [2]. Later, instruments were built to better study the stars; the telescope became the best tool for gaining an understanding of astronomy and cosmological events. Still the technology

used to find solutions to the mysteries of the universe could not really help to show how the universe has evolved. The interest in knowledge about the universe escalated after the first man landed on the moon. Questions about what held the universe together were then posed more than ever before. There is no shortage of science fiction stories about dark energy, dark matter, and parallel universes to keep us entertained. With advanced technologies the door to explore those mysteries has been opened and the research done with them has brought answers that are nothing less than astounding. Observatories now exist for the sole purpose of pursuing celestial and terrestrial studies. They include institutions that conduct research in astronomy through equipment housed in laboratories here on earth as well as satellites that have been launched into space to observe matters and send the information back to earth. NASA currently has several such satellite observato-

ries orbiting the earth.

The Rossi X-Ray Timing Explorer observatory, one of the early satellites, was launched by NASA in 1995 to collect data about changes in space and black holes. Its specialty lies in observing fast-moving, high-energy objects in space. It is designed to point rapidly to virtually any position in the sky. Its ability to measure flux changes in X-rays within one ten-thousandth of a second makes it useful for tracking neutron stars.

Another satellite is the Chandra X-Ray Observatory. This satellite was launched on July 23rd, 1999. It is another of NASA's system of observatories whose mission is to lead scientists in the right direction to answer questions about the evolution and functions of space [13]. It has four major components to collect useful data

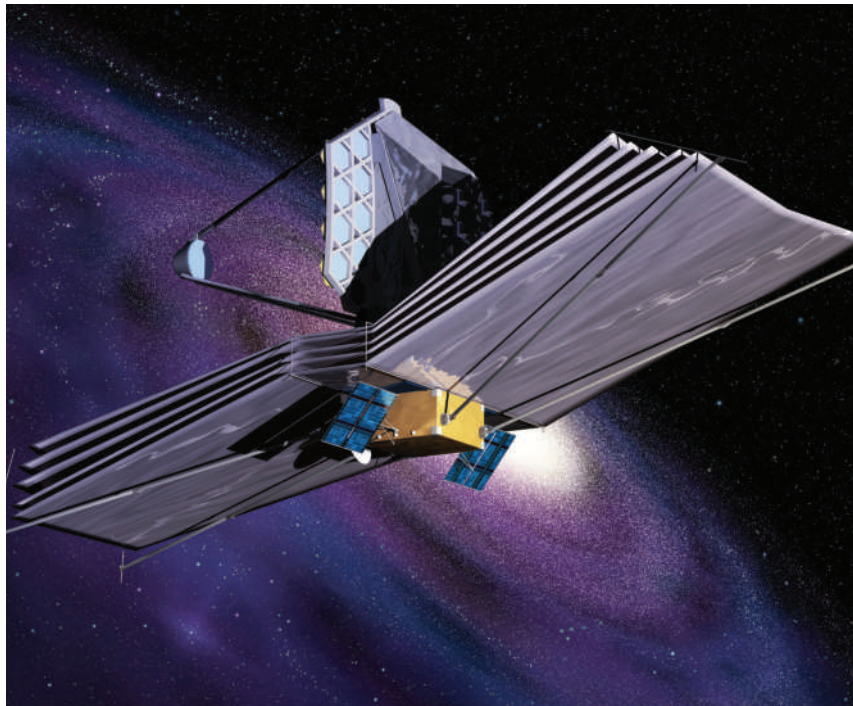
about space: an Advanced CCD Imaging Spectrometer; a High Resolution Camera comprised of two micro-channel plate imaging detectors; a High Energy Transmission Grating for spectroscopy of bright energy sources; and a Low Energy Transmission Grating for spectroscopy of bright, soft courses such as white dwarf atmospheres [10].

One of the great mysteries of astrophysics is the potential existence of dark energy. Dark energy is the term given to the force that is drawing galaxies away from one another at an accelerated pace; its opposite is the gravity which draws them closer. Its existence has yet to be proven; though the effects observed in the universe have led researchers to postulate its existence [6]. Its structure is still undefined but through the data collected by the Chandra

Observatory, scientists now believe that dark energy is a repulsive form of gravity which dominates the universe [7]. The Chandra Observatory has unique capabilities that go beyond dark matter research. It also works towards finding answers about black holes. Light observed from black holes manifests an interesting phenomenon called "heartbeat". Recently the observatory has provided astronomers with information enabling them to learn more about what

drives these heartbeats [1]. With the use of the Chandra Observatory and the Rossi X-ray telescope, scientists have gained new insights into how black holes control their intake and restrict their growth in outer space.

From the birth of the universe to the death of a star, there are still so many questions that have yet to be answered. The European Organization for Nuclear



Research, CERN, is working diligently to find the truth about the origins of the universe. The famous Large Hadron Collider is a particle accelerator that is so large that it stretches from Switzerland to France, completely underground. Located at CERN, this instrument is used to study the smallest known particles in order to understand how the universe we live in came into being. The idea is to understand the functions of the universe by studying the smallest particles that compose it. Scientists at CERN are trying to recreate the conditions that occurred at the time of the "Big Bang." They do this by setting up particle accelerators with two beams that are set off to collide with each other. Each is filled with subatomic particles called "Hadrons," composite particles made up of elementary particles or quarks

In Search of Life in the Universe

Andrew Deek



Introduction

So far, Earth appears to be the only life-supporting planet. However, scientists are examining evidence indicating that some forms of life may have existed, or still do, in other parts of our universe. An understanding of current and past forms of microbial life on Earth has informed the investigation of life in the extreme environments of extraterrestrial planets. Astrobiology, the study of life in the universe, is a scientific field that aims to understand the origin of life, how it has evolved within the environment in which it began, and, most importantly, whether it may be present in places beyond Earth. This paper examines the research and development efforts supported by the United States Government agencies, national laboratories, and universities seeking to explore the very distant lands beyond our own Earth with a particular curiosity for learning about other possible life forms, intelligent or not, that may be sharing our universe.

Astrobiology - The Study of Life in the Universe

Astrobiology is a multidisciplinary field that combines elements of the natural sciences including astronomy, biology, chemistry, ecology, geography, physics, and planetary science to investigate the possibility of life, past and present, in any form, on other planets [20]. The search for life outside of Earth, based on hypotheses, predictions, and interpretation of existing scientific data, explores the possibility of Earth-like life that may have evolved on other planets similar to ours. However, this does not rule out the possibility of life that may be different from what we know, one that we may have even stumbled on, but did not recognize [3].

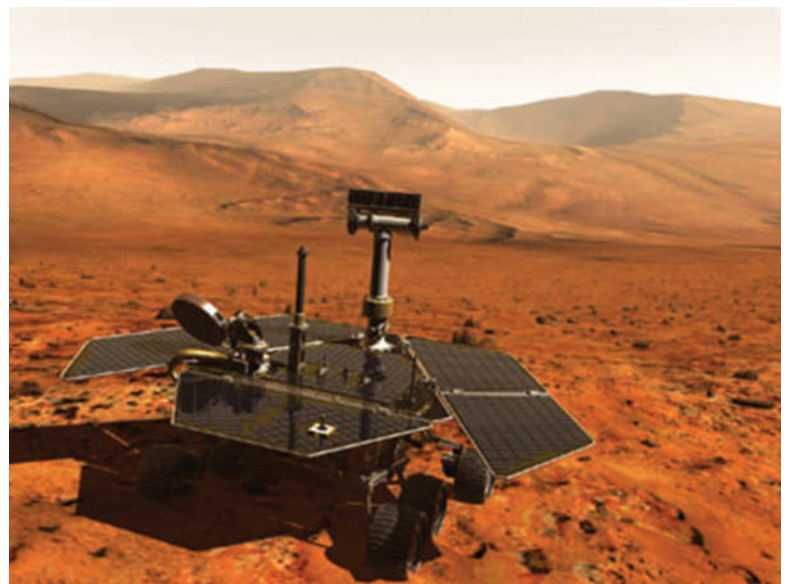
Astrobiologists are even more motivated in their search for extraterrestrial life since they have found amino acids, the building blocks of proteins, in a meteorite formed at a temperature of more than 2,000 degrees Fahrenheit as a result of two asteroids

colliding. Fragments of Asteroid 2008 TC3 with a total mass of 3.95 kg, the first celestial object that has ever been spotted before slamming into Earth's atmosphere, were found in the Nubian Desert area of northern Sudan in March 2009 subsequent to its disintegration at an altitude of 37 km in October 2008 [8]. Although the excessive heat should have destroyed the organic compounds of the Asteroid 2008 TC3, scientists were able to find them. This "suggests that there is more than one way to make amino acids in space, which increases the chance for finding life elsewhere in the Universe" [6]. For the first time, this discovery gave rise to a theory that a chemical model for life may be possible without the presence of oxygen and water, opening up the possibility that extraterrestrial life might be found at a number of sites outside the solar system.

Our Solar System, formed about four billion years ago, is part of a galaxy known as the Milky Way that is composed of billions of stars, which along with other galaxies that exist outside it, make up the universe [2]. Planets outside the solar system are referred to as extrasolars or exoplanets. With the universe continuously expanding since its original formation, roughly fourteen billion years ago, it is a challenge for scientists to observe and study most matters within their far reaches [19]. Despite technological advancements, direct evidence of exoplanets remains difficult to obtain by scientists who have imaged a very small number of them via telescopes. One reason for this is that such planets are far away and consequently difficult to see. Another reason is that exoplanets are particularly dim as compared to their parent stars. However, many more exoplanets have been detected through indirect methods. Therefore, for now, the detection of Earth-like planets and possible life forms on them using present instruments is challenging. Much progress on this front, though, has been made by exploring planets within our solar system and studying life in the extreme environments on Earth.

Exploring the Universe for Evidence of Life

President Kennedy's declaration before a joint session of Congress half a century ago on May 25, 1961 spoke of "landing a man on the moon and returning him safely to Earth within a decade." This was a challenge met, successfully and on time, on July 20, 1969 when Astronaut Neil Armstrong became the first human to step on the moon. The fact that the Russians had already launched their first satellite into space in 1957 and a Russian Cosmonaut was the first human to orbit Earth in 1961 played a role in the United States' eagerness to score another first [5]. In the next few years, a series of other successful lunar landing and walking missions took place. Accomplishing this national goal gave confidence to a young organization, the National Aeronautics and Space Administration (NASA), which was created by Congress and President Eisenhower on October 1, 1958 by an "Act to provide for research into the problems of flight within and outside the Earth's atmosphere, and for other purposes", namely national defense [10]. Even though biological research was not at the heart of these lunar missions, the desire to answer the question of life on some of the other planets ultimately found its way into the core of NASA's projects.



A simulated image of the Mars Rover showing the Mars Sundial on the rear solar panel [9]

Acknowledging the increased importance of biological science research in space exploration, NASA established the National Astrobiology Institute (NAI) in 1998, which consequently gave recognition to the field of astrobiology [1]. In addition to its NASA charge, NAI works on integrating the multitude of astrobiology research and education programs offered by national and international scientific organizations. Meteorite ALH 84001, supposedly originated from Mars and found on December 27, 1984 in Allan Hills, Antarctica, was partially responsible for propelling this NASA-funded astrobiology program into the limelight when it was widely announced in 1996 that scientists believe the meteorite contains evidence for microscopic fossils of Martian bacteria [12]. This rock, determined to be the oldest known igneous rock from Mars with a mass of 1.93 kg (4.2 pounds), is presumed to have crystallized from molten rock 4.091 billion years ago [9]. McKay and his team provide evidence that ALH 84001 was penetrated by water while it was still on Mars and conclude that there is primitive life on Mars because they found evidence of dead, fossil bacteria and chemical traces that might have come from bacteria present inside the 3.6 billion years old carbonate mineral globules in ALH 84001. This was presumably formed when Mars' atmosphere was much warmer and liquid water more abundant.

However, not everyone in the scientific community was quick to endorse NASA's assertion of Meteorite ALH 84001's evidence of primitive bacterial life on Mars. In 2009, thirteen years after their initial declaration, NASA scientists reopened the extraterrestrial Martian life debate, reaffirming their original assertion that Meteorite ALH 84001 shows evidence of microscopic life on Mars. They contend

that Martian meteorites have distinct microbial fossils offering strong evidence that life had, at least at one time, existed there [17]. To be sure, the debate on what constitutes life is not likely to draw closure any time soon with hundreds of different definitions of life found in the literature and an internationally accepted definition still lacking [18]. The lack of such a definition, although necessary for astrobiological research, does not seem to have hindered scientific and technological efforts from continuing the search for extraterrestrial life.



Depiction of NASA Mars Rover [10]

The Definition of Life Reconsidered

Recent government-funded science research in the United States and other countries in support of understanding the origin and evolution of life on Earth and elsewhere in the universe has greatly altered the prevailing wisdom and accepted scientific theories about "life as we know it". The complex biochemistry of life has been influenced by a variety of factors, including biological, chemical, environmental, physical, as the well as the powerful means of

natural selection [4]. It has been established that cell molecules are made up of atoms of a small number of elements, forming the basic building blocks of all life that exists on Earth, namely carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur. It was thought that all living organisms contain these six important elements with no exceptions [15]. Recently, however, scientists studying life in the extreme environments of Earth and analyzing the survival of microbes under such conditions have uncovered a completely new kind of life, one that replaces phosphorus with arsenic in its cell components.

The Technology of Discovery

One of the most important items the Rovers have is their Panoramic Camera. This camera is able to capture pictures of Mars that identifies the minerals, formations, and structures of landmarks. A second camera on the Rovers is the Microscopic Imager that obtains high-resolution images of rock and soil samples. Another tool in their repertoire is the Miniature Thermal Emission Spectrometer, or Mini-TES. This tool is oriented toward the atmosphere for temperature readings on Mars, identifying certain rocks and soils, and for determining how these Martian rocks were formed. To compliment the Mini-TES, the Alpha Particle X-Ray Spectrometer (APXS) is used for closer analysis of the different elements that rocks and soils are compounded of. Each Rover is equipped with magnets allowing the robot to collect magnetic samples of rocks and soils that the Mössbauer Spectrometer and the Alpha Particle X-ray Spectrometer can analyze. These spectrometers can determine the ratio of magnetic particles to non-magnetic particles in rocks and soils, but also in particles of dust floating near the Rovers that the Rock Abrasion Tool can dig up while it unearths fresh material for the robot to analyze [16].

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Conclusion

Since the start of space exploration, scientists have wanted to learn of possible habitable environments on other planets by looking for evidence of life, past or current, that resembles our life on Earth. Until the Mono Lake discovery, it was not known that life, different from ours, already existed on our own planet. Although some scientists questioned whether the arsenic-based bacteria tested by the NASA researchers were indeed completely deprived of phosphorus, at the least this discovery has shown that other biochemistries of life may exist and such combinations have yet to be imagined by researchers. Of course, our forever expanding galaxy contains an endless number of stars, presenting a real dilemma in our quest for life on distant planets. There are some that ponder if the presumed life on other planets may be engaged in its own similar search looking for us, while others wonder whether this hoped-for encounter will be a good thing.

The famed Astrophysicist Stephen Hawking, one of the world's leading scientists, suggests that extraterrestrials almost certainly exist. However, he is as certain that we should be doing all we can to avoid them. His reason is simple: Other life forms may be as intelligent as we are, possibly even more intelligent, and thus they could pose a devastating threat to humanity [7]. Presenting this as a choice between satisfying normal human curiosities as opposed to risking the awakening of a "sleeping giant" makes it obvious as to what will prevail considering that human history points to a clear inclination for discovery.

SpaceX

Declan Tonna

[11]



It seems as though much has changed since humanity made its first push into the reaches of space. It may be difficult to grasp through the haze of everyday life but today thousands of man-made satellites orbit outside of our planet's atmosphere; men and women live and work for months on end inside orbiting mobile space stations; rockets and spacecraft are being tested, sent into space and retrieved at increasingly frequent intervals. Yet, at the same time not much has really changed when looking at the wider picture. Today's launch vehicles remain little differed from those of 40 years ago. Launch methods as well have been left without major innovation. In an era when most technology follows a path of ever-increas-

ing capability and reliability this seems a bit out of place, does it not?

Enter Space Exploration Technologies Corporation or "SpaceX," a privately funded commercial space organization based on the philosophy that simplicity, low-cost, and reliability could go hand in hand. Founded in 2002 by current CEO and CTO and previous founder of the PayPal and Zip2 corporations Elon Musk, SpaceX has since established a notable launch manifest (spacex.com/launch_manifest.php) including research and development tasks, demonstration flights and space station resupply missions with such patrons as NASA, Bigelow, Astrium and Space Systems, among others. SpaceX has also been



The Dragon Cargo/Crew Vessel [12]

awarded funding in excess of \$1.6 billion through the Commercial Orbital Transportation Services (COTS) program in 2008 launched by NASA approximately four years earlier in an attempt to demonstrate cargo spaceflight transportation and spark outside interest in space exploration via the Space Act Agreement Between National Aeronautics and Space Administration, Kistler Aerospace Corporation and Rocketplane Limited for Commercial Orbital Transportation Services (COTS). NASA's 2010 budget included \$39 million for the funding of the COTS program, under which SpaceX is developing rockets and capsules such as the Falcon9 and the Dragon that will ferry cargo to the NASA space station in progress, initiated by the recent "Discovery" mission on a commercial basis after the aforementioned space shuttle series retires. Just this year, NASA had boosted its investment in SpaceX's logistics service being developed for the international space station by \$40 million, and plans to double that payout during the year [1].

SpaceX aims to improve upon the methods of conventional spaceflight and realize their philosophy of simplicity, low-cost, and reliability through developing a family of launch vehicle types, namely the Falcon 1, Falcon 9, Falcon 9 Heavy rockets, and the Dragon cargo/crew vessel. The Falcon series in general is able to deliver spacecraft into any inclination and altitude, from low Earth orbit to geosynchronous orbit to planetary missions. The Falcon 9 and Falcon 9 Heavy are also designed such that all stages are reusable, making them the world's first fully reusable launch vehicles. The Dragon crew and cargo capsule, currently under development, will revolutionize access to space by providing efficient and reliable transport of crew and cargo to the International Space Stations (ISS) and other LEO destinations [2].

The Falcon 1 (70m x 5.5m, 35,180kg) was the first and most famous launch of the SpaceX Corporation. It is a two-stage, liquid-oxygen and rocket grade kerosene powered launch vehicle. The primary structure is made of a space-grade aluminum alloy in a flight pressurized architecture designed by SpaceX while the tank structure is composed of an aluminum-lithium alloy possessing the highest known strength-to-weight ratio of any aluminum in the market. A single SpaceX Kestrel engine powers the Falcon1 upper stage and a highly reliable and proven TEA-TEB pyrophoric system is used to provide a multiple restart capability on the upper stage which allows for drop off at different altitudes and inclinations [2].

The main focus in the design of the Falcon1 was reliability with the use of the minimum amount of engines. Therefore, there has been only one Kestrel engine developed for each stage of the Falcon 1. Another notable point is the SpaceX "hold-before-release system," a capability required by commercial airplanes, but not implemented on many launch vehicles. After first stage engine start, the Falcon is held down and not released for flight until all propulsion and vehicle systems are confirmed to be operating normally. An automatic safe shut-down and unloading of propellant occurs if any abnormal conditions are detected.

Like Falcon 1, Falcon 9 (54.8m x 3.6m, 333,400kg) is a two-stage, liquid oxygen and rocket grade kerosene powered launch vehicle. It uses the

same engines, structural architecture, avionics, and launch system. The Falcon 9 tank walls and domes are made from the very same aluminum-lithium alloy. The interstage, which connects the upper and lower stage for Falcon 9, is a carbon fiber aluminum core composite structure. The separation system is a larger version of the pneumatic pushers used on Falcon 1. The main difference, however, is in its propulsion. Nine SpaceX Merlin engines power the Falcon 9 first stage with 125,000 lbs-f sea level thrust per engine for a total thrust on liftoff of just over 1.1 million lbs-f. After engine start, Falcon 9 is held down until all vehicle systems are verified to be functioning normally before release for liftoff like its counterpart. The second stage tank of Falcon 9 is simply a shorter version of the first stage tank and uses most of the same tooling, material, and manufacturing techniques. A single Merlin engine powers the Falcon9 upper stage as well. For added reliability of restart, the engine has dual redundant pyrophoric igniters.

Also like the Falcon 1, the main design focus with the project was reliability. However, unlike the Falcon 1, the Falcon 9 boasts 9 Merlin engines clustered together, as previously mentioned. This vehicle will be capable of sustaining an engine failure at any point in flight and still successfully complete its mission. This actually results in an even higher level of reliability than a single engine stage. The SpaceX nine engine architecture is an improved version of the architecture employed by the Saturn V and Saturn I rockets of the Apollo Program, which had flawless flight records despite losing engines on a number of missions.

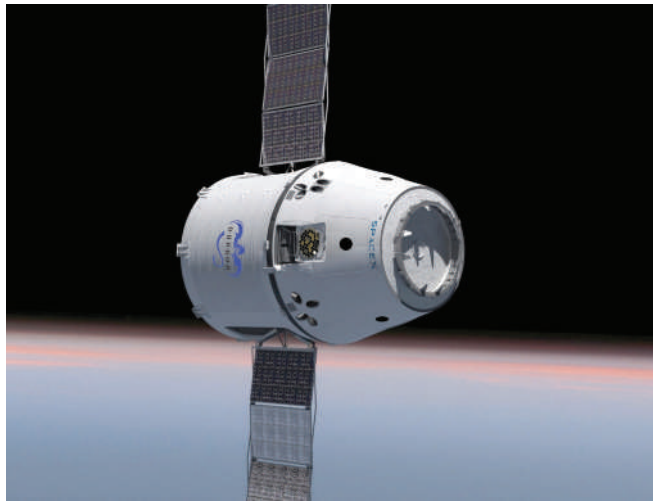
Finally, the Dragon is the most recent and ambitious SpaceX exploit to date. It is a free-flying, reusable spacecraft being developed by SpaceX under NASA's COTS program. Initiated internally by SpaceX in 2005, the Dragon spacecraft is made up of

a pressurized capsule and unpressurized trunk used for Earth to orbit transport of pressurized and unpressurized cargo, and/or crew members. The Dragon spacecraft is comprised of three main elements: the Nosecone, which protects the vessel and the docking adaptor during ascent; the Spacecraft, which houses the crew and/or pressurized cargo as well as the service section containing avionics, the RCS system, parachutes, and other support infrastructure; and the Trunk, which provides for the stowage of unpressurized cargo and will support Dragon's solar arrays and thermal radiators.

The Dragon as well as Falcon 1 and Falcon 9, as advanced and economically revolutionary as they are, are part of the start of what hopefully becomes a trend; that is what SpaceX is and what it was founded for, a privatized research and development company with the goal of developing a cheaper and more efficient method of space travel.

The science of space travel has taken humanity down a long and often dangerous path, but regrettably the field has greatly lost public attention in recent years. NASA itself lost much of its government funding

due to economic cutbacks in the United States, leading internally to massive layoffs, halts to research missions and launches, and worst of all a loss of the public eye. Amidst the growing disinterest in the field of space travel it falls into the hands of organizations like SpaceX to help "re-pioneer" space and make the dream of traversing that great emptiness, ignited in 1961 with the first men in space, a clear and solid reality.



Depiction of SpaceX in flight [13]

Dale E. Gary, Ph.D.
Distinguished Professor, Department of Physics
Director, Owens Valley Solar Array
Center for Solar-Terrestrial Research

Interview By Mousa K. Hamad

One of the biggest mysteries that lingered over the shoulders of man was put to rest less than five hundred years ago when Nicolaus Copernicus proposed his heliocentric theory placing the Sun at the center of the solar system. The Copernican Revolution set the stage for future astronomy and cosmology as we know it. Since then, modern science has greatly increased our understanding of the workings of the Sun and its effects on our day-to-day life. Dr. Dale Gary, a Distinguished Professor in the NJIT Physics Department and a nationally renowned astronomer, has been working diligently at the Center for Solar-Terrestrial Research to explore the mechanisms of magnetic field disturbances and their effects on wireless signals commonly utilized by modern technology. Dr. Gary is the Director of the Owens Valley Solar Array, which currently features a series of seven antennas that serve to measure the magnetic field strength of the Sun at thirty-nine frequencies. The dedicated array is unique to the United States, making the collected data very important for the analysis of the effects of changes in solar-magnetic activity. After the data is collected, it is recorded to hard drives and then shipped from the California facility to NJIT, where it is analyzed and sorted.

The data collected by the Owens Valley Solar Array is not Dr. Gary's only research project. He is also currently developing two more instruments, including the Frequency-Agile Solar Radiotelescope Testbed (FST). Dr. Gary's research focuses on the Transient Energetic Phenomena, specifically mechanisms of energy release, electron acceleration, electron transport, and the formation and destabilization of large scale structures. Coronal magnetic fields present another field of study for Dr. Gary. The Owens Valley Solar Array (OVSA) is used to measure the magnitude of coronal magnetic fields, the tempo-

ral evolution of the magnetic fields; it also provides insight into the role of coronal currents and the storage and release of magnetic energy (for more on this, please see OVSA.njit.edu). Another very interesting aspect of research undertaken by Dr. Gary involves comparing solar flares (outbursts of magnetic energy from the Sun) and their effect on cell phone signals and GPS units. A solar flare that occurred at the end of 2006 resulted in the creation of radio waves, which spread to Earth and resulted in a fifteen-minute outage of Global Positioning Systems (GPS). "These solar flares injected high-energy electrons into the solar upper atmosphere and produced radio waves that spread to Earth, covering a broad frequency range. Those radio waves acted as noise that degraded the signal used by GPS and other navigational systems." [1] Dr. Gary's new five million dollar grant from the National Science Foundation will allow him to expand OVSA from seven to fifteen antennas, as well as modernize the control system and many other components with new state-of-the-art technology, which will significantly increase the quality and quantity of data collected.

In the field of research, it is easy for one to write volumes on the accomplishments and implications of Dr. Gary's research and scholarly work, making it obvious why he was awarded the College of Science and Liberal Arts "Excellence in Research Award" this past year at the University Convocation. A side that is often neglected is Dr. Gary's love of lecturing. Ali Mustafa, a Junior in Physics, says of Dr. Gary: "He is one of the best professors I ever had. I hope he will teach classical mechanics next semester." There you have it, a professor who is known among his peers as a renowned scientist and by his students as a master-teacher.

Katia Passerini, Ph.D.

Associate Professor, School of Management

Interview By Bishoy Hanna

Splitting her time between discipline-based and pedagogical research, Dr. Katia Passerini, Associate Professor of Management, manages a highly successful career at NJIT. Dr. Passerini has been with NJIT's School of Management for nearly nine years. With keen interest in teaching, she is currently focusing a significant portion of her research efforts on understanding team-based learning. Realizing that the three different modes of educational delivery, face-to-face, online, and hybrid, which are being used require different pedagogical and technological approaches, Dr. Passerini is currently pursuing work with a group of colleagues from other departments here at NJIT as well as faculty from other universities to identify best practices for teaching and learning in all three of these modes. Dr. Passerini and her team do this by seeking the opinion of students in various courses and analyzing their feedback. She also links back these results to students' own performance and grades. Dr. Passerini uses a mix of qualitative and quantitative approaches in carrying out her research with a focus on pre- and post-testing that allows for careful examination of students' knowledge and mastery of the subjects taught, before starting the course and after it is concluded. As to what additional changes in educational delivery she foresees in the near future, Dr. Passerini acknowledges that the diversity of methods in place appear to be functioning well now; she would not, however, be surprised if the mobile phones soon take center stage in the classroom.

In addition to focusing on this pedagogical work, Dr. Passerini is interested in understanding the fundamentals of knowledge generation and management within the context of business and government. Her practical experience with the World Bank, which she gained right after she completed her PhD, took her to the South Pacific Islands where she investigated how a country creates and improves knowledge within its borders.

In order to address this issue, Dr. Passerini applied a model of study that focused on the knowledge-creation index. This index takes into account the country's education system, infrastructure, political system, support for economic development, and reward for innovation. The resulting data is supposed to represent the ability of a country to advance the current state of knowledge by integrating new information that will in turn benefit the country's governing and development processes. While this work is still on-going, Dr. Passerini has focused her own research efforts on knowledge creation and management from the business perspective. Ultimately she wishes to learn if the same knowledge-creation factors that apply to macro-scale environments such as countries, can be applied to smaller units, like a company.

Relating also to business and the development of enterprise is Dr. Passerini's practitioner-focused research, which she takes keen interest in because of her desire to remain connected to business in order to apply the results of her studies in industry. In this area of her work, Dr. Passerini is attempting to learn of different ways to use digital devices to positively influence a company bottom line. Some of her ideas include increasing employees' productivity, introducing creative consumer marketing strategies, and improving communication across company administration through the use of mobile technologies. Dr. Passerini's discipline-based and pedagogical research that forms the corner stone of her academic expertise converge in her practical, organizational mobile technology investigations. This is evident by her integration of learning systems and knowledge generation techniques as fundamental ingredients to organizational management. Dr. Passerini believes that her research frameworks and results have the potential to accelerate the development and growth of business in this country and therefore help in the economy's rebound by creating new jobs and generating new consumers.

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