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Introducing Astrophysics and Cosmology as Part of Multi-Disciplinary Approaches to Liberal Arts Courses Addressing “The Big Questions” of Human Experience

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Abstract: There is an opportunity to bring college students to the exploration of the grandeur and wonder of the universe through the design and crafting of courses for the university and liberal arts curricula that would develop multi-disciplinary perspectives within the frames of reference of astrophysics and cosmology. There is broad interest within colleges and universities to provide courses that examine “The Big Questions” of human experience from a variety of perspectives. The study of the history of discoveries and insights that we have gained through the development of astrophysics and cosmology provides course options for students to use to explore these questions. Such hybrid courses enable students to approach the questions of origins, human existence, appreciation of the natural world, appreciation of the universe at large, and the significance of our evolving comprehension of the universe from a variety of disciplinary perspectives, including those that border on the astrophysical and cosmological domains. There are within such courses opportunities to examine historical, philosophical, theological, and cultural perspectives as they intersect with our scientific understanding of where and who we are. The first of these courses at Sacred Heart University has been developed and presented for the past 2 years as part of the new Core Curriculum. The development of that course, entitled “The Journey in the Physical Universe”, will be discussed, and insights will be shared.

Starting in 2007, faculty members from the College of Arts and Sciences at Sacred Heart University (SHU), in Fairfield, CT, initiated a program for entering students, known as the Common Core curriculum. The description of this program as presented on the SHU website is:

“Common Core: The Human Journey immerses students in a coherent and integrated understanding of the arts and sciences. It develops critical/analytical skills and abilities as well as engages students in the Catholic intellectual tradition as rigorous intellectual inquiry.

The Human Journey focuses on four fundamental and enduring questions of human meaning and value: 1. What does it mean to be human? 2. What does it mean to live a life of meaning and purpose? 3. What does it mean to understand and appreciate the natural world? 4. What does it mean to forge a more just society for the common good?”

(http://www.sacredheart.edu/pages/18771_common_core_the_human_journey.cfm)

SHU students must participate in certain courses, some of which they may select from a menu of courses offered as part of the Common Core (CC). In their freshmen year students must take foundation courses designed to build skills of academic discipline, improve clarity of thought and sharpen skills in research and communication. These include courses such as: HICC 101: The Human Journey: Historical Paths to Civilization and ENCC 102: Literary Expressions of the Human Journey. In their sophomore and junior years the students may select from a variety of courses in the “CC 103A: Social and Behavioral Sciences – The Human Community: The Individual and Society” and/or the “CC 103B: Natural Sciences – The Human Community and Science Discovery”. During their senior year the students engage in their “Capstone Common Core Course - RS/PHCC 104: The Human Search for Truth, Justice, and the Common Good”. Over the entire experience students will have taken 4 or more courses in which they will examine the “four fundamental and enduring questions” of the Common Core in the context offering a rich variety of subject areas to sample and broaden their academic and intellectual horizons. Simultaneously, they will be able to hone their skills as scholars, by being engaged in academic practices related to what is known as the “Catholic Intellectual Tradition”.

“The Catholic intellectual tradition is a collection of characteristically Catholic concepts, habits, and values that have been developed in a variety of disciplines and through an intercultural conversation lasting over 2000 years. Among the Catholic intellectual tradition’s central claims are that (1) humans exist in relation to a Triune God; (2) God’s presence is mediated through the particular; (3) morality is objective and knowable; (4) human knowledge can be connected into a coherent whole; (5) faith and reason work together to provide understanding of the world; and (6) humans have inviolable dignity and are responsible toward the common good.” [Adapted from a summary description, entitled “THE HUMAN JOURNEY: Describing the Catholic Intellectual Tradition” By: *Brian Stiltner, Associate Professor of Religious Studies*, SHU. Additional detail regarding the CIT can be found at the SHU website: http://www.sacredheart.edu/pages/234_the_catholic_intellectual_tradition.cfm]

Within this academic setting the author of this paper embarked in the Fall Semester of 2008 on the development of a physics-related course to complete the set of courses under the “CC 103B: Natural Sciences – The Human Community and Science Discovery” group. Since courses in biology and chemistry had been developed previously, and were up and running, physics was the last to be added. The research, design and development of the curriculum for the course, entitled PYCC 103: “The Journey in the Physical Universe”, took place during the Fall Semester 2008, and a seven-student pilot section was launched in the Spring Semester 2009. Formative and summative assessments of the course were conducted, and appropriate changes were made for full implementation in the 2009-10 academic year, with one regular section offered each semester. Formative and summative evaluations of curriculum and instructional design have been carried out since that time, with changes made as needed, and the course is now beginning its third year of operation, with 2 sections available to students each semester.

The design of the curriculum for “The Journey in the Physical Universe” is focused on five overall course goals which are related to the “Catholic intellectual tradition” and each of the four fundamental and enduring Common Core questions. These are then woven into the fabric of the course as threads of continuity as each of the topics relating to the physical universe are examined from not only the scientific perspectives, but also from the historical, philosophical,

and theological perspectives as well. In this manner the students are able to consider the multiple dimensions of our understandings, and how those understandings have changed over the history of human inquiry about the universe within which we live and are a part of.

The formal statements of the five course goals are presented in the Syllabus as follows:

“Through the “PYCC 103: The Journey in the Physical Universe” course, students will be able to demonstrate their use of aspects of the Catholic Intellectual Tradition (CIT) to gain:

1. an understanding of the ways in which we have historically altered our view of the physical universe through the applications of the methods of scientific reasoning, and the ways that these views have informed our understanding of God and His Creation.
2. the ability to examine how the ways in which our understanding of the interaction of physics and faith provide us with the keys to help us realize what it means to be human.
3. insight into the way in which an understanding of the physical universe, in the context of faith, can help people enhance their ability to live deeper lives of meaning and purpose.
4. an increased appreciation and understanding of the natural world as seen from the frame of reference of the sciences, particularly as seen in the context of physics and astronomy.
5. a realization that the ways in which we choose to utilize our knowledge of the physical universe, and to apply the technology derived from that knowledge to meeting human needs, is a reflection of wise stewardship involving the interaction of faith, knowledge and reason to serve the common good.”

In order to engage the students in substantive reading related to these goals, the following books were selected for use as course texts:

Francis S. Collins, **The Language of God: A Scientist Presents Evidence for Belief**,
New York: Free Press, 2006.

Ian G. Barbour, **When Science Meets Religion**,
New York: HarperCollins Publishers, Inc., 2000.

Hugh Ross, **Why the Universe is the Way It Is**,
Grand Rapids, MI: Baker Books, 2008.

John Polkinghorne, **Quantum Physics and Theology: An Unexpected Kinship**,
New Haven: Yale University Press, 2007.

Krista Tippitt, **Einstein’s God: Conversations About Science and the Human Spirit**,
New York: The Penguin Group, 2010.

The division of the coursework for the semester is distributed over 26 75-minute class sessions. Each session begins to address a primary question, based on one of the 5 course goals, and then opens several secondary questions for the students to think about as we engage in the various in-class discussions, conduct various demonstrations, consider various models, and see various video segments related to the topics being considered. Out-of-class assignments involve the students in reading, discussion, viewing and listening to on-line audio or video resources, naked-eye sky observations and conducting research on topics of interest. Each activity generates some type of written or calculated response which the students submit electronically via email. Each in-class activity and out-of-class activity calls for a period of reflection, and a written response summarizing what of greatest significance has been learned, and what personal reaction the student has to that. These multi-sensory assignments to “read, view, observe,

reflect, react and write” activities have been considered to be extremely valuable components of the students’ learning experiences, as expressed in their summative course assessment.

The course content is subdivided over the semester as follows, with each, major goal-related segment covering 4 or 5 days, and each class meeting labeled as a letter of the alphabet:

I. What are the dimension of physics and the dimension of faith, and how do they relate to our knowledge of the universe?

- A. Epistemology - How do we know what we know? What is faith, and what is science?
- B. Where are you (u)? What is the large-scale size and structure of the universe (U)?
What does the size and scale of the U have to do with our sense of human significance?
What does the size and scale of the U have to do with our characterization of God?
- C. How has our understanding of size and scale in the universe changed over time?
Modeling the Earth, the Earth-Moon System, and the Solar System.
- D. What is the scale of the universe in time?
How has our view of this time-scale changed over time?
What is the universe like on the small scales of space and time?

II. How does our knowledge of the physical universe, in the context of our faith, relate to our humanity?

- E. What does it mean to be “human”?
- F. How do we, on the human-scale, fit into the universe of space and time?
- G. How does faith inform our understanding of our humanity and our place in the U?
- H. Where does the human journey begin on the: “space” dimension? “time” dimension? “spiritual” dimension?

III. How does our awareness of and knowledge of the physical and the spiritual universe enable the realization of meaning and purpose in our lives?

- I. What is reality?
- J. Why are we here?
- K. What is truth? (VERITAS?)
- L. How does the human “desire to know” relate to:
our search for knowledge, our spiritual quest, and our understanding of the universe?

MX. THE MID-TERM EXAM

Once the first 3 segments of the course have been completed, the students write their Mid-Term Exam responses. They are able to utilize their notes, written reflections and written reactions to respond, and to examine concepts that have been presented through in-class experiences or through their out-of-class work. Through this exam students indicate that they are able to pull together concepts of space, time, and our humanity to realize how our understanding of the universe has developed over the history of human exploration. Once again the significance of paradigm shifts seems to have greater meaning in the retrospective opportunity offered by this exam.

During the second half of the course, the details of some of the major concepts of physics are used to consider developing understanding of the universe on all scales of consideration, from the scales of everyday experience, to the cosmological scales, to the quantum mechanical scales. The changes in our human understanding of who and where we are from ancient cultures, to pre-Copernican conceptions of natural philosophy, to the birth and development of classical physics, to the revolutionary discoveries of atomic, nuclear, and quantum mechanical physics, to the discoveries of modern astrophysics and cosmology, to the major questions that lie before us today all enable students to see how conceptions of “reality” have grown and developed. The importance of the development of scientific models of the design and functioning of the universe is then related to the developments of technology which extends our intellectual reach, and enables our application of that technology to the improvement of the “common good”. As can be seen in what follows, the work in section IV of the course focuses on the development of the physics of the natural world as it allows our greater appreciation of the universe on all levels. It is then followed in section V of the course by the consideration of applications.

IV. How does our knowledge of the principles of physics enable us to appreciate the natural world?

- N. Scientific models and reality. Early conceptions of the motions of objects on Earth, the motions of the Earth itself, and the motions of objects in the heavens.
- O. The “mechanical universe” of physics: Copernican, Galilean, and Newtonian Models.
- P. Fundamental forces (“interactions”) in the universe, and the nature of matter/energy.
- Q. The behavior of particles and the behavior of waves – sound, Earthquakes, light?.
- R. The nature of light – wave/particle duality, and the “misbehavior” of particles – quantum physics.
- S. Atomic and nuclear physics, quantum physics and theology.
- T. The origin and nature of the universe. The origin of the Solar System.
- U. Why does the universe function on the basis of fundamental mathematical laws?
- V. Is the universe a product of chance or a matter of purpose? Can we know?

V. How does our knowledge of and application of the principles of physics in the context of our faith, enable us to improve our society for the common good?

- W. How do science, faith and our place in the world relate? Do science and faith conflict? What about the case of Galileo? What distinguishes science, faith and religion?
- X. How can we use scientific knowledge and technology for the “improvement” of society? What about the case of: nuclear energy? nuclear weapons? What guides our decision making?
- Y. What role does faith have in dealing with our personal future and the future of society? What about the cases of natural and man-made disasters? How are we best able to cope with reality? (H. G. Well’s story “The Star”)
- Z. What is our source of hope? Will science and technology save us from disasters? How should we define wise stewardship? Are you simply a product of blind chance or a person of purpose?

The PYCC 103 course concludes with a summative Final Exam designed to enable students to draw together the concepts and ideas related to the course, and to synthesize responses reflecting deeper thought and understanding than they had on entry to the course, of the universe and themselves within it.

Students' reactions to the course as expressed in their responses to course evaluations reflect a broad range of opinion and perspective. Most seem to be very satisfied with the experiences that they have had, and the amount that they have learned. Several have commented on the value that they have derived from having to think deeply about the universe as we know it today, and about consideration of their own "worldview" with respect to their spiritual relationships. Some have said that they have never worked so hard, but found it to be so intellectually satisfying. A year or two ago, one student commented, "This is the first course that I have taken, where I feel that I have gotten my money's worth."

[A subsequent version of this paper is scheduled for Publication in: **2011 Proceedings of the Astronomical Society of the Pacific.**]