Santa Clara University
Department of Electrical Engineering
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Winter 2023

ELEN 160: Chaos Theory, Metamathematics and the Limits of Knowledge: A Scientific Perspective on Religion

REQUIRED READING:

1. Aleksandar I. Zecevic, *Truth, Beauty and the Limits of Knowledge: A Path from Science to Religion*, Cognella Academic Publishing, 2019.

2. Aleksandar I. Zecevic, *The Unknowable and the Counterintuitive: The Surprising Insights of Modern Science*, Cognella Academic Publishing, 2019.

3. John Haught, *Science and Religion: From Conflict to Conversation*, Paulist Press 1995.

4. John Polkinghorne, *Belief in God in an Age of Science*, Yale University Press, 1998.

COURSE OBJECTIVES AND SCOPE

There is a widespread belief among scientists and engineers that science and religion are essentially unrelated areas of human inquiry. According to this outlook (which is sometimes referred to as the 'doctrine of non-overlapping magisteria'), science ought to limit itself to factual questions about nature, and religion should deal with issues related to meaning and value. As long as this distinction is observed, there is no apparent reason why the two disciplines should not coexist peacefully.

Although the proposed approach provides a sensible compromise, there seems to be something rather artificial in such a strict separation. Indeed, since religion represents a global view of the world, it must necessarily make claims that concern nature and our place in it. As such, it is bound to conflict with science on a variety of issues (miracles, evolution and the creation of the universe come to mind immediately). If we are, therefore, inclined to be realistic (as scientists and engineers ought to be), we should assume that there is a significant overlap between theology and science, and consider the consequences.

The main purpose of this course is to examine a number of key theological claims, and evaluate whether they have a rational justification from a scientific perspective. In thinking about what the term "rational" means in this context, it is useful to recognize that our actions and opinions are guided by what physicist (and historian of science) Gerald Holton describes as a "robust, map-like constellation of … beliefs about how the

world as a whole operates." He refers to this overall outlook that shapes our attitudes as a *Weltbild* (which is a somewhat broader German word for "world view").

Although the *Weltbild* of any given individual depends to a large extent on his social, ethnic and educational background, it is fair to say that it always contains a subset of beliefs that pertain to the natural world. It is perhaps here that we might locate an appropriate meaning for the attribute "rational," at least when it comes to scientifically minded individuals. It is reasonable to assume that for such a person, a coherent world view would be one that satisfies the following two conditions:

1) The set of "core" beliefs about the natural world must be compatible with existing scientific knowledge.

2) The "non-scientific" core beliefs should be consistent (at least in some measure) with the scientific ones.

In applying these criteria, it is important to keep in mind that the term "consistent" must be used somewhat loosely. Indeed, I seriously doubt that the entire mindset of any individual could pass a strict test of logical soundness (which is perhaps what makes us human in the first place). With that in mind, one could argue that the rationality of our *Weltbild* can be justified by establishing appropriate "logical bridges" between the disparate clusters of views that constitute it. Formal proofs are of little use in this enterprise, and should ultimately give way to analogies and metaphors.

What is it about analogies and metaphors that makes them so suitable for this purpose? The primary motive for focusing on these two modes of description stems from the fact that they have always been a natural tool for explaining difficult concepts, both in science and in theology. If these two disciplines are seen as manifestations of the same overarching reality (as Christian theology suggests), then it is perfectly reasonable to assume that analogies can also help bridge the apparent gap that separates them. From a theological perspective, what we are really proposing here amounts to adding a certain number of "scientific" metaphors to the already existing traditional ones. The potential value of such metaphors has been recognized by several contemporary thinkers:

> "Metaphors 'fund' theology, providing the language and images out of which theological concepts grow; they describe the unknown in terms of the known. … When metaphors lose their original meaning and fruitfulness, the theology built upon them must be reconstructed, drawing upon new metaphors appropriate for a new age… It seems reasonable that physics, as well as biology and the other sciences which infuse our culture, can be a source of religious metaphors." *Robert J. Russell*

In order to draw the appropriate analogies, it will be necessary to consider a number of scientific theories in some detail. The primary focus will be on chaos theory, with metamathematics, quantum mechanics, relativity and string theory as supplemental topics. Since each one of these areas entails very advanced mathematical skills, the course clearly meets (and probably exceeds) the standard requirements for a technical elective in engineering. Unlike other electives, however, in this case the technical

knowledge is *not* an end in its own right. It is rather a *means* for a better understanding of the theological and philosophical issues that will be raised.

The course is structured in a way that allows us to treat scientific and theological topics in parallel. What this means is that every technical issue will be accompanied by a theological question that is in some way related to it. This dialogue should provide an opportunity to compare scientific and religious perspectives, and to explore ways of reconciling possible differences.

What should engineering students hope to gain from a course like this? At a minimum, they will acquire insights into some of the most perplexing phenomena of modern science. The fact that the subtle workings of nature are often thoroughly counterintuitive ought to excite some curiosity and a sense of wonder. It is true, of course, that not all of us share this kind of enthusiasm. Those who are indifferent to such matters are probably better off taking a more marketable technical elective, with less math and more applications. It is important to make this clear since some of the material is difficult, and cannot be mastered without proper motivation. Those who persevere, however, will develop a set of sophisticated analytical tools that will enable them to think independently about these issues, and possibly harmonize their religious beliefs with their profession on a deeper level. It is my hope that those who take the course will continue this line of inquiry long after their formal education is completed.

LEARNING OUTCOMES

Students who successfully complete this course should be able to:

1. Solve systems of nonlinear algebraic equations using numerical techniques.
2. Analyze the stability properties of linear and nonlinear dynamic systems.
3. Distinguish between different types of attractors (including those that characterize chaotic behavior).
4. Identify different types of bifurcations in dynamic systems with varying parameters.
5. Grasp the philosophical and theological implications of chaos theory, in the context of phenomena such as intermittency and hypersensitivity to initial conditions.
6. Understand the interplay between chance and lawful behavior in complex systems, particularly as it pertains to the emergence of novel forms of organization in nature.
7. Understand the epistemological limitations of scientific explanations, and relate this knowledge to the theological method of inquiry.
8. Analyze and compare different philosophical and theological positions in the existing literature on science and religion (using at least three sources).
9. Reflect on their own views about religion and relate them to their scientific training.

Outcomes 1 – 4 will be evaluated through homework assignments, a midterm exam and a project (in Matlab). Items 5 – 9 will be assessed through weekly class discussions, the online discussion forum and through the final essay.

GRADING

Project 15%
Homework 20%
Midterm Exam 25%
Final Essay 25%
Class Participation 15%

PROJECT. One project will be assigned, with an emphasis on the analysis and simulation of chaotic systems using Matlab. You will be expected to do a fair amount of programming (in the context of Matlab m-files). Students can work in pairs (a single report is required for each group).

HOMEWORK There will be three homework assignments, which are actually "mini-projects." Each of these assignments will require both theoretical work and Matlab simulation. Students can work in pairs (a single report is required for each group).

MIDTERM EXAM. The Midterm exam will focus on the material covered in the first six weeks of class. It will include topics such as the analysis of linear and nonlinear dynamic systems, stability and bifurcations.

ESSAY. In the final essay, you will be asked to provide your own views regarding the relationship between science and religion. You are expected to select one of the ten theological questions discussed in class and expand on it. You may combine several questions or perhaps propose some of your own; however, all such modifications will be subject to approval by the instructor. The essay should include the theoretical background for your discussion, as well as an explanation for your choice of topic (I would like to know why a particular question is more interesting to you than some others). *I will also expect you to elaborate on how the theological and philosophical positions proposed in Haught's and Polkinghorne's books relate to your arguments*.

The paper should be 8-10 pages long, and will be due on the first day of finals week. The specific claims and opinions that you choose to express in the essay are entirely up to you (bear in mind that agreeing with me won't get you any extra points!). You will be graded on the quality of your arguments and your understanding of the material discussed in class (in particular, Learning Outcomes 5 – 9). Writing skills such as clarity, grammar, and style *do* matter, and will be a factor in my grading.

ONLINE DISCUSSIONS AND CLASS PARTICIPATION. Each of the weekly theological questions will require some preliminary reading on your part (the relevant sections of the lecture notes are indicated in the syllabus). Although I will review these topics and clarify the main concepts, I will expect you to come prepared.

The emphasis in this component of the course will be on class discussions and participation in the online forum. In order to get credit, you will have to post your views on six different topics, according to the following schedule:

Topic 1: Week 1
Topic 2: Weeks 2-3
Topic 3: Weeks 4-5
Topic 4: Weeks 6-8
Topic 5: Week 9
Topic 6: Week 10

In each of the postings, you will be expected to address one of the assigned questions (or several, if you wish), and respond to at least one other person's posting.

The amount of credit given for this component (from 0 – 15%) will depend both on the frequency and the quality of the postings, as well as your activity in class. Note that the topics for the first and last online discussion are *fixed*. In the other discussions, you can choose from a range of suggested questions.

LECTURES

Technical topics in this class will be covered in the recorded lectures that are available on Camino. I will expect you to view the appropriate modules (which are indicated below) *before* our Tuesday meetings. In these meetings I will provide clarifications and answer questions, but this will not be a "traditional" lecture. Instead, we will focus on practice problems. Our Thursday lectures will be devoted to theological questions, and will require some preliminary reading. All the readings listed below refer to the first textbook in the syllabus: *Truth, Beauty and the Limits of Knowledge: A Path from Science to Religion*.

Week 1 Introduction

Theological Topic:
Unknowable truths in science and math
Reading: Chapters 2 and 4

Week 2 ***Technical Topic***:
Linear systems
View: Modules 1 and 2

Theological Topic:
Unknowable truths in science and math (ctd.)
Reading: Chapters 5 and 6

Week 3

Technical Topic:
Introduction to nonlinear systems
View: Module 3

Theological Topic:
Truth and knowledge
Reading: Chapter 3 and Section 9.1

Week 4

Technical Topic:
Introduction to nonlinear systems (ctd.)
View: Module 4

Theological Topic:
Some fundamental theological questions
Reading: Sections 9.2 – 9.3

Week 5

Technical Topics:
Types of attractors
View: Module 5

Characteristics of chaos
View: Module 6

Theological Topic:
Attributes of God and the human experience
Reading: Section 9.4

Week 6

Technical Topic:
Fractals
View: Modules 7 and 8

Theological Topic:
Miracles
Reading: Section 10.1

Week 7

Technical Topic:
Bifurcations
View: Modules 9 and 10

Theological Topic:
Evolution
Reading: Section 10.3

Week 8

Midterm Exam (Tuesday 02/28)

	Theological Topic: Religious pluralism Reading: Section 10.4
Week 9	***Technical Topic***: Paths to chaos View: Module 11
	Theological Topic: Ethics, science and theology Reading: Sections 8.1 – 8.3
Week 10	***Technical Topic***: Paths to chaos (ctd.) View: Module 12
	Theological Topic: Aesthetics, science and theology Reading: Sections 7.1 – 7.3

PATHWAY INFORMATION

This course is associated with the "Paradigm Shifts and the Nature of Human Knowing" pathway. If you declare a pathway in this area you may use a representative piece of work from this course in the Pathway Portfolio that you will complete during your senior year. It is recommended that you keep electronic copies of your work."

GENERAL INFORMATION

OFFICE:	SCDI 4025 – O
OFFICE HOURS:	Tuesdays and Thursdays, 4:00-5:00, and by appointment.
PHONE:	(408) 554-2394
E-MAIL:	azecevic@scu.edu
WEBSITE:	http://www.engr.scu.edu/~azecevic/

Academic Integrity Pledge:

The Academic Integrity pledge is an expression of the University's commitment to fostering an understanding of—and commitment to—a culture of integrity at Santa Clara University. The Academic Integrity pledge, which applies to all students, states:

"I am committed to being a person of integrity. I pledge, as a member of the Santa Clara University community, to abide by and uphold the standards of academic integrity contained in the Student Conduct Code."

Academic integrity is part of your intellectual, ethical, and professional development. I expect you to uphold the principles of this pledge for all work in this class. I will clarify expectations on academic integrity as needed for assignments and exams. If you have questions about what is appropriate on any assignment, please let me know before you hand in work. For more resources about ensuring academic integrity in your work, including the appropriate use of course sharing sites such as Chegg, see this site created by the SCU Library at https://libguides.scu.edu/academic-integrity or visit www.scu.edu/academic-integrity.

Safety Measures

In order to meet our learning objectives, we will adhere to the highest standards for safety and mutual respect. I expect everyone to adhere to current university mask mandates at all times; to make their best attempt to make themselves heard when asking questions or contributing to discussions; and refrain from eating or drinking in class. It is expected that everyone will follow university guidelines about health and public safety measures outlined in the emails that was sent to students and their families on August 31, 2021.

Office of Accessible Education

If you have a documented disability for which accommodations may be required in this class, please contact the Office of Accessible Education (oae@scu.edu, http://www.scu.edu/oae) as soon as possible to discuss your needs and register for accommodations with the University. If you have already arranged accommodations through OAE, please be sure to request your accommodations through your myOAE portal and discuss them with me during my office hours within the first two weeks of class.

To ensure fairness and consistency, individual faculty members are required to receive verification from the Office of Accessible Education before providing accommodations. OAE will work with students and faculty to arrange proctored exams for students whose accommodations include double time for exams and/or assistive technology. Students with approved accommodations of time-and-a-half should talk with me as soon as possible. The Office of Accessible Education must be contacted in advance (at least two weeks notice recommended) to schedule proctored examinations or to arrange other accommodations.

In light of shifting health advisories related to COVID-19, exams may be administered online. Students with approved testing accommodations should contact me (at least two

weeks notice recommended) prior to an exam date to notify me of their intent to use their testing accommodations on the upcoming exam to ensure their accommodations are effectively implemented.

Discrimination, Harassment and Sexual Misconduct (Title IX)

SCU faculty are committed to helping create a safe and open learning environment for all students. If you (or someone you know) have experienced any form of discrimination, harassment or sexual misconduct, including sexual assault, dating or domestic violence, or stalking, know that help and support are available, I encourage you seek support and report incidents to the Director of Equal Opportunity and Title IX Coordinator, Belinda Guthrie, at 408-554-3043, bguthrie@scu.edu. For more information about reporting options and resources at Santa Clara University and in the community, please visit https://www.scu.edu/title-ix/. If you wish to speak with a confidential resource, please visit https://www.scu.edu/title-ix/resources/student/.