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Cover Photograph: 1128 sunspot drawing by John of Worcester. This is the earliest known drawing of a sunspot from anywhere in the world. https://en.wikipedia.org/wiki/John_of_Worcester#/media/File:John_of_Worcester_sunspot_drawing_1128.png

Editorial Comment:
On behalf of the Alabama Academy of Science, I would like to express my gratitude and appreciation to the reviewers for their valuable contributions in reviewing the manuscripts of this issue.

Thanks!
Brian Toone
Editor: Alabama Academy of Science Journal

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EXTRA

DOES KNOWING PHILOSOPHY MAKE A SCIENTIST A BETTER SCIENTIST OR DOES KNOWING SCIENCE MAKING A PHILOSOPHER A BETTER PHILOSOPHER?

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Introduction

In this paper I contrast two ways philosophy and science can relate and influence each other. On one side, I present René Descartes' metaphysical defense and justification for 17th century science. On the other side, I present the contemporary philosopher John Heil's claim that metaphysics must be based on the latest findings of fundamental physics. I argue for the second claim, not because science is a superior intellectual pursuit but because of the importance and role of "experience" in both scientific and philosophical inquiry.

Descartes' Metaphysical Foundation for Natural Science—A "Top-Down Ontology"

A deep paradox was felt in the 17th century. It witnessed the tremendous advance in natural-scientific knowledge and also a growing skepticism about the foundations of knowledge. Even though earlier figures as Gian Francesco Pico and Rabelais had introduced the skepticism of Pyrrho to Europe, it was Michel de Montaigne (1533–1592) who exposed it to a wider audience, especially through his Apology of Raymond Sebond. Pyrrhonic skepticism as expressed by Sextus Empiricus and picked up in the 16th century made four primary claims: the first two on humanity's cognitive limitations, and the second two on the proper sapient goals:

1. The problem of relativism: there are conflicting opinions about reality, and each is somewhat rationally defensible, dogmatism about reality is untenable since its ends up begging the question and, particularly, pleading its claim.
2. The problem of foundations: any evidence given to support a dogmatic conclusion about reality also needs evidence, and that evidence needs evidence, and ad infinitum; knowledge cannot be about reality in itself, only appearances.
3. The goal of disbelief: as a consequence of numbers 1 and 2, we should suspend judgments about reality.
4. The goal of tranquility: as a consequence of numbers 1–3, we find wisdom through ataraxy (the general disinvestment of all ultimate concerns) and thereby gain an inner tranquility.

Montaigne asserted, because "of the uncertainty and weakness of our senses" and because "there is no existence that is constant, either of our being or of that of objects." (Montaigne, 542, 553), we cannot believe with epistemological certainty that the form of our ideas accurately matches the form of objects in the world.

Descartes was enough of a modernist to think skepticism could not be dismissed, but he also was enough of a mathematician and natural scientist to think there had to be a type of knowledge that skepticism could not undermine. Descartes promoted the Copernican view of a mechanistic

nature operating by laws. Such a view exemplified his metaphysical claim that all matter is actually "extension governed by force." Matter follows mechanistic laws and thus can be scientifically explained, and because Copernicus had correctly discerned these laws, his view of the solar system must be correct. For Descartes, much was at stake in defending Copernicus.

He wanted to overcome, with metaphysical certainty, the prevalent skepticism of his day. We first need to establish a metaphysical truth and then consider the physical theories consistent with it. We need to link our knowledge of the world to the reality of the world, and Descartes thought he found this evidence in the idea of God as a non-deceiving, Perfect Being. He says, "I must examine whether there is a God as soon as an opportunity occurs, and if I find that there is one, I must also investigate whether he can be a deceiver; for as long as this is unknown, I do not see that I can be certain of anything" (Descartes, Meditations, 35). Only a perfect and infinite being can cause the idea of a Perfect Being to an imperfect and finite thinker, and with this idea, we can trust what we know about the world, because God would not deceive us about the material-spatial dimensions of reality. We are absolutely certain of that, so claimed Descartes. Just as it is certain that we exist because we think, we are certain the world exists and functions as it would be created by a Perfect Being.

Descartes believed he could not base the epistemic certainty of science upon our experience of the world or of what science could present to us (for example, telescopic observations). Montaigne's skepticism taught him that no empirical experience of the world is indubitable. However, Descartes' approach is not totally removing the importance of experience. In his meditations, Descartes experienced and discovered the idea of a perfect being, which he explained cannot be fabricated by the thinking self. The idea of a perfect being shows itself in our pure reasoning, and the thinking-self appropriately responds by explaining that the perfect being cannot by nature deceive and thus cannot deceive us about the reality the world. Even though Descartes did not base his metaphysics on the experience of the world, he did base it on the a priori experience of a perfect being. Our certainty of God's existence provides an epistemic certainty of the world's existence and subsequently provides an epistemological foundation for the laws of nature.

Descartes interests were not only to construct an internally consistent and coherent system of ideas, but he also wanted to overcome skepticism with a coherent and consistent metaphysical system and thus provide a foundation for science. To do this he had to show a connection with reality; to show this he needed probative evidence, and that evidence was the self-evident idea of God as a non-deceiving Perfect Being. Albert William Levi sums up clearly Descartes agenda, "The Cartesian movement from the self to God, and from God to the external world, is less a truly metaphysical speculation in the medieval sense than a hypothesis essential for the validation of all knowledge about the physical world" (Levi, Philosophy as Social Expression, 169). With this metaphysical claim, Descartes believed he established the certainty of science and propelled his era into a modern, scientifically informed culture. This is a "top-down ontology" providing justification for the trustworthiness of science.

John Heil's Physical Basis for Metaphysics— "A Bottom-Up Ontology"

John Heil is a professor of Philosophy at Washington University in St. Louis, Missouri. He specializes in metaphysics, and in 2012 published The Universe As We Find It. His main interest is to articulate and defend what he calls a "fundamental ontology." He uses the traditional vocabulary of metaphysics (that is, substance, properties, causality, etc.) to clarify what represents the building blocks of the way we experience the universe. Metaphysics is not necessarily basic science, but it relies on science to tell it what it needs to clarify conceptually. The business of the metaphysician is not to discover what non-philosophers cannot know but to understand the intellectual implications of what basic science says about the universe. Even though a physicist may not use traditional philosophical terms like substance and properties, these terms help us understand the relationship between our ordinary experiences of the world and the fundamental elements of physical reality. In this sense, a physicist can do science without knowing the vocabulary of metaphysics, even though metaphysical claims are always implied in any description of the way the universe is. However, metaphysical terms are meaningful only if they actually refer to what fundamental physics says is the ground of our physical experiences of the universe.

Of course, Heil acknowledges that not all scientific activities aim (not even all that goes under the name of physics) to uncover the nature of existence per se, but all knowledge claims about the universe rely on what he calls a "truthmaker" about the world. Fundamental physics explores what these truthmakers are and informs us about them. Truthmakers are about what must be for us to know the world truly. They are the ontology of our truthful knowledge of objects and their relationships. Our knowledge is true when there is an internal relationship between our judgments and representations about the world and these truthmakers. By internal, Heil means what makes the judgment and representation coherent with the truthmaker. We do not need to postulate an external reality that makes the judgment true (Heil, The Universe, 9-10). Consequently, when we seek to know truly how the universe is, we need to know (what Heil calls) the "deep story" of the universe, we need to know what the most basic feature of physical reality must be if our knowledge about the world is true. "Fundamental physics provides a glimpse of what lies at the basis of all the world truths: the buck stops with fundamental physics" (Heil, The Universe, 166).

Key to Heil's approach to metaphysics is the use of the word substance. For him, it is the right word to equip philosophy to explore generally about existence as being (Heil, The Universe, 167). The word has a long history, with Plato and Aristotle showing how differently it can be used. For Plato, the substance is the most basic element of reality, and it never is not itself. Thus, a genuine substance (not the mere appearance of it) would not change, being purely formal and not material. Consequently, a substance must be in the "world of Being," not the "world of Becoming," and what we experience in the world only participates with its true substance in an eternal realm. Hence, the truthmaker of any proposition about the world is whether the claim has an eternal implication.

However, Aristotle thought differently. The truthmakers for metaphysics come from physics. Because we want to describe the world, our metaphysical explanations must be traceable back to our experiences of the world made clear by physics. Our understanding of substance as the basic reality must therefore be about how we experience the world. Consequently, because the only world we know changes, substance must also change. Change is

real, not an appearance of reality. Consequently, a substance must be a formed matter that can remain itself as it changes (that is, in shape, place, and time). The metaphysician then relies on physics, and a true proposition about the world is whether it informs us more about the way the world is. In fact, Aristotle writes a book on physics before he writes his book on metaphysics.

Heil is on Aristotle's side. We philosophize about the universe not based on abstract a priori categories of being but upon how we experience the world. Heil thus issues the blunt claim near midway in the book that "When philosophy and science cross swords, only the fool sides with the philosopher. Science rules" (Heil, The Universe, 137). That is, if philosophy wants to use its analytic skills to explain why the world is the way it is, then it needs to know the "deep story" about the physical makeup of the world, and fundamental physics tells that story. Even though philosophy uses the categories of substance and properties to describe being, fundamental physics tells us what the beings are (Heil, The Universe, 25). It is the case that fundamental physics has not settled on what the nature of existence is—for example, a particle, a quantum force, or possible space-time. This uncertainty in fundamental physics does not make metaphysics suspect as an intellectual discipline. Hence, the agenda of the metaphysician is to explain our general experience of the universe with confidence that the substance or substances of the universe are what fundamental physics say they are (Heil, The Universe, 287).

Of course, Heil knows that fundamental physics changes its explanations of the basic physical stuff of the universe and, also, that one of its most captivating theories is the confusing claims of quantum physics. Hence, for intellectual coherence, physics needs the conceptual clarity and stabilizing factor of a basic ontology. Contemporary physics is more often expressed in elaborate mathematical models than in Aristotelean terminology, and Heil is not insisting that physicists adopt Aristotle's vocabulary of substance and properties. Yet, Heil does maintain the vocabulary of substances and properties undergirds both scientific inquiry and our general impressions that the universe is constituted in such a way that we can make truth claims about the universe. The use of the metaphysical terms of substances and properties to refer to the truthmakers provided by fundamental physics can assure us that we are indeed making truth claims about the universe, whether we talk of electrons or red tomatoes (two of his favorite examples). For Heil, the importance of using substance metaphysic is so certain that "If you take away the substances, if you take away the properties and the arrangements, you take away the universe" (Heil, The Universe, 42). Substance really does refer to something. With fundamental physics continually evolving its basic conclusions about physical reality, our use of the metaphysical vocabulary of substance can assure society that regardless of the conclusions of physicists, we have their accounts of the fundamental objects to provide the truthmakers in our efforts to know truly the universe whether in its manifestations of common experiences (for example, red tomatoes and tables) or in its exact and precise scientific renditions (for example, electrons and force fields).

Even though fundamental physics informs us of the truthmakers of the universe, for two reasons fundamental physics, according to Heil, cannot replace the usefulness of ontological descriptions offered by metaphysis. First, "[philosophy] provides an accounting of the basic ontological categories" (Heil, The Universe, 279). This accounting expands the usefulness of the terminology of physics into broader descriptions of the universe and utilizes the insights of fundamental physics to render a systematic, metaphysical explanation of the universe. Second,

with its ontological categories (for example, propertied substances), ontology "[provides] an account of relations among the various sciences, a role no science, including fundamental physics, is equipped to play" (Heil, The Universe, 279). The narrow focus of fundamental physics is not readily applicable to chemistry, biology, astronomy, etc., and, thus, we cannot reduce all sciences to just physics. However, by deeming what fundamental physics says is the basic physics of the universe to be the propertied substance/s of the universe, we are able to correlate the other sciences to physics through the concepts of propertied substances. For example, we can talk of the substance of biological life without conceptually moving past the actual living things to concentrate on the basic physical realities. Just as we can speak meaningfully to each other about red tomatoes and tables without talking about particles, forces, or space-time, we can speak meaningfully about biology and psychology as well. In other words, it would be wrongheaded and incoherent to try to reduce all knowledge of the universe down to fundamental physics.

Heil has critics. For instance, Joseph Baltimore ("Heil's Two-Category of Ontology and Causation") contends Heil has not given a persuasive account how propertied substances actually are able to relate to each other. Javier Cumpa ("Factualism and the Scientific Image,") argues that Heil does not adequately explain how our common experiences actually relates to the findings of fundamental physics. Also, Michael Esfeld ("Factualism and the Scientific Image,") reasons that Heil's over reliance on the Aristotelean language of substance and properties does not provide meaningful ways to describe what contemporary physics is doing. These are serious challenges, and Heil most recent book on metaphysics (What is Metaphysics, Polity Press, 2021), we could say, is his effort to respond to the critiques and explain further his particular approach to doing metaphysics. For instance, throughout the book he addresses what can be called the Sellars' paradox—if the manifest image of a table, for example, does not resemble the scientific explanation of the table (electrons, forces, etc.), then how can they both be true (Heil, What is Metaphysics, 25ff). He develops further the role of truthmakers and his response is serious and worthy of attention, but my main interest in this paper has been Heil's insistence and effort to associate the philosophical enterprise of metaphysics to the pursuits of fundamental physics, to what physicists maintain is our most basic experience of the universe.

Philosophy and Experience

Heil relies on a "bottom-up ontology" to do good philosophy, whereas Descartes bases scientific certainty on a "top-down ontology." Who is right? I think Descartes misuses philosophy in the way he fortifies science against skepticism. He bases his argument on the certainty of God's existence experienced in the reflection on the idea of God as a Perfect Being. For Descartes, we experience the idea, and it is a "clear and distinct idea," indubitable. No doubt, we can think of a God as a Perfect Being, and for Descartes, because it is an experience located in our philosophical reflections, God must exist and must not be a deceiver. Even though there is a lot of philosophical interests in such a possibility (that is, the logic of it and that it is a mental state), Descartes errs in making the certainty of a scientific explanation of the world based upon the certainty of a "clear and distinct idea" experienced in reflecting on the idea of God. If he had concentrated solely on the logical possibilities of God's existence due to the thought of a Perfect Being, Descartes would have stayed within the boundaries of the

philosophical enterprise, but instead, he overstepped those boundaries by believing an experience in philosophical meditation can be the primary experience on which science can be based.

Although Heil utilizes philosophical reflection to talk about the universe as we find it, he uses the vocabulary and analytical skills of philosophy to describe and help explain the primary experience of the universe offered by fundamental physics. I contend that in terms of doing metaphysics his is the right approach, not because physics is a smarter discipline than philosophy or that physics is more culturally indispensable than philosophy, but because Heil uses philosophical analysis more consistently with the nature of doing philosophy. Philosophy is the intellectual reflection on the forceful and consequential experiences of nature. Its task is like the owl of Minerva; it flies at dusk (so said G.W.F. Hegel). That is, the wisdom that philosophy offers comes after we experience arresting and important aspects of nature, morality, beauty, and God.

I think John Dewey's explains well this understanding of the work of philosophy. He states:

> "There is a special service which the study of philosophy may render. Empirically pursued it will not be a study of philosophy but a study, by means of philosophy, of life-experience. But this experience is already overlaid and saturated with the products of the reflection of past generations and by-gone ages. . . If they are not detected, they often obfuscate and distort. Clarification and emancipation follow when they are detected and cast out; and one great object of philosophy is to accomplish this task" (Dewey, Experience and Nature, 34-35).

Of course, there is the mental experience of doing philosophy, but it is a matter of reflection and understanding, not a matter of the objects of the world. For Dewey, we experience the world (which he often used "Nature" to mean) in many different ways (Dewey, Experience and Nature, 24), and we develop unique and specialized ways to explore and explain these experiences. Nature manifests itself in these and through these experiences. For instance, those who study beauty, art, and the aesthetic experiences of them do not create the experiences but reflect on them. The same with morality, religion, etc.

Admittedly, the word experience, though widely used, is vague, used to refer to a physicist's acknowledgement of sub-atomic particles as well as to the mystic's praise of God. Obviously, the type of experiences we have varies with the ways we encounter the objects in the world. Some experiences are clear and quantifiable, whereas others are opaque and impressionistic. However, each experience involves an activity of an aware-self interacting with objects, relations, or the whole of what is possibly experienced. In the various experiences, we respond to what arrests our attention. In physics, we respond to physical aspects of the world. In morality, we respond to forceful obligations. In aesthetic taste, we respond to objects suggestive of beauty or an overall purpose, and so on. Hence, we can say experience refers to the multiple ways humans respond and engage the world.

It is not the task of philosophy to claim a special privilege to these experienceable objects of Nature but to clarify their logical implications for other intellectual pursuits and to explain their importance for culture. Albert William Levi expresses well this Deweyan agenda of philosophy as the critical reflection on primary experiences, "Before there can be philosophy, there must be

experience" (Levi, Varieties of Experience, 4). In Dewey and Levi's approach, even though philosophy often uses abstract language and rigorous logical analysis, its agenda is thoroughly humanistic for it tries to explain the importance of what science, morality, art, religion, etc. say for and about the human condition as evolved in a culture. Philosophy has a long history of serious, insightful, and culturally impactful thinkers with a specialized vocabulary and manner of analyses, but that history displays how to do philosophy as a manner of reflection on the salient and formative experiences raised within a culture, not as though providing the primary experiences for science, art, morality, religion, etc. Philosophy can assist science integrate its purposes and findings into the formation of a culture, but it cannot provide or replace the basic experiences that makes scientific inquiry unique and illuminating of the world. This is Heil's approach, and, though critics are raising serious questions about his accounting of metaphysics, it is an intellectually compelling philosophy of science.

Perhaps I am presenting a too monolithic view of contemporary philosophy. As an academic discipline, philosophy is a coat of many colors, and some philosophers would show little interest in what Heil is doing. There is no one way to do philosophy, but my reason for highlighting Heil's contributions is that if we are looking for ways to clarify the relationship between philosophical metaphysics and science, his approach is fruitful, because he attempts intelligibly to explain (especially with his notion of "truthmakers") the connection between our general experiences of the world and the way science accounts for the universe.

Does this appreciation of Heil's approach rule out any importance we can give to Descartes? No. His focus and clarification of the mental experience of the idea of God as a Perfect Being is provocative in that it may illustrate the uniqueness of the idea of God and a way to apply modal logic to conceive of God. Consequently, we can say that modal reasoning (that is, the relationship of what is necessarily the case to what is possibly the case) about God can possibly logically clarify a fundamental human mental experience.

However, Descartes' fault in offering a philosophy of science was to abstract philosophy out of the cultural confines of his age and to presume he had found a metaphysical experience (that is, "the clear and distinct idea" of God as a Perfect Being) on which science could successfully overcome skepticism. Although Descartes was convinced a mathematical-mechanistic physics is right about the world, his metaphysics does not help us understand what that physics actually describes. He attempted a philosophy of science built on a mental abstraction not derived from the life-experiences of nature. This is where he went wrong. It is wrongheaded, as well as unhelpful to science.

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SIMPLE METHODS FOR PREDICTING THE SIZE AND TIMING OF SUNSPOT CYCLE 25: ADDITIONAL REMARKS

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ABSTRACT

A simple method based on the number of continuous months bounding sunspot minimum occurrence with smoothed monthly mean sunspot number R <20 (i.e., N(R<20)) is found to be useful for predicting the size and timing of a sunspot cycle (SC). In particular, an SC having N(R<20) <19 months tends to have a larger sunspot minimum (Rm) and maximum (RM) amplitude and a shorter ascent (ASC) and period (PER), while an SC having N(R<20) ≥19 months tends to have a smaller Rm and RM and a longer ASC and PER. SC25, the present ongoing cycle, had N(R<20) = 43 months, suggesting Rm = 5.6 ± 4.6, RM = 144.2 ± 43.5, ASC = 59 ± 14 months and PER = 132 ± 14 months. Instead, based on inferred regression equations and using N(R<20) = 43 months, SC25 is expected to have Rm = 3.6 ± 2.8, RM = 130.9 ± 39.7, ASC = 62 ± 11 months and PER = 137 ± 14 months. For SC25, Rm = 1.8 occurred in December 2019 and R exceeded 116.4 (SC24's RM) in February 2023. Therefore, SC25's RM will be larger than that observed for SC24 and not smaller. For SC25, RM = 148.5 ± 21.1 is the projected value based on the average of several techniques for estimating RM. Such a value means the 2-cycle moving average for SC24 will be 140.4, some 32 units of sunspot number below that observed for SC23, further suggesting that SC24, indeed, marks the beginning of another three to five cycles of extended intervals of low sunspot number minimum- and maximum-amplitude cycles.

INTRODUCTION

Sunspot cycle (SC) 25 continues growing in amplitude (i.e., smoothed monthly mean sunspot number R), having surpassed the maximum amplitude (RM) of SC24 (116.4) in February 2023 (117.9). Indeed, the early behavior of SC25 is strongly suggestive that it is a slow-rising-long-period sunspot cycle (i.e., one having an ascent duration, ASC, equal to 49 months or longer and period, PER, equal to 133 months or longer) with maximum amplitude occurrence expected on or after January 2024 (Wilson 2022). Prior to its onset, speculation suggested that SC25 likely would be a relatively small cycle with maximum amplitude similar to that of SC24, or smaller (cf. https://en.wikipedia.org/wiki/Solar_cycle_25), and that, perhaps, this would be an indication of the imminent occurrence of another Maunder–like or Dalton-like minimum (i.e., an extended period of low sunspot number spanning several decades; cf. Hoyt and Schatten 1996; Russell, Luhmann and Jian 2010; Feynman and Ruzmaikin 2011; Zolotova and Ponyavin 2014; Zachilas and Gkana 2015; Usoskin, Arlt, Asvestari et. al. 2015; Javaraiah 2017; Singh and Bhargawa 2019).

In this study, the lengths (i.e., number of months) of the continuous intervals bounding Rm (minimum amplitude) having R <20 (i.e., N(R<20)) are determined for SC00-25 and linear

regression analysis is performed between Rm, RM, ASC and PER against N(R<20). The inferred correlative relationships are then used to predict, in particular, Rm, RM, ASC and PER for SC25. Also examined is the likelihood that SC24-25, and possibly SC26 and beyond, represents a recurrence of another Dalton-like minimum, a reflection of the Centennial Gleissberg Cycle (Gleissberg 1965; Feynman and Fougere 1984; Feynman and Ruzmaikin 2011).

METHODS AND MATERIALS

Smoothed monthly mean sunspot number R is taken from http://sidc.oma.be/silso/datafiles to determine N(R<20), Rm, RM, ASC and PER for SC00-25. 2-cycle moving averages (2-cma) are employed to show trends in the cyclic values, where the 2-cma is representative of the variation of the Hale cycle (i.e., two consecutive sunspot cycles). Recall that the Sun's magnetic cycle spans two consecutive sunspot cycles, with the northern hemisphere displaying positive-leading polarity of sunspots and the southern hemisphere displaying negative-leading polarity in odd-numbered sunspot cycles, being reversed in even-numbered sunspot cycles (Howard 1977).

RESULTS AND DISCUSSION

Table 1 gives the cyclic values of N(R<20), Rm, RM, ASC and PER for SC00-25. Also given are the means, standard deviations (sd) and medians (med), both for the entire grouping of SC00-25 and for the two subgroupings based on the median value of N(R<20) = 19 (i.e., those having N(R<20) less than 19 months and those having N(R<20) greater than or equal to 19 months), and the results of runs testing for randomness (Lapin 1978). Of the various parameters, only RM is found to be non-randomly distributed, having a normal deviate $z = -2.17$. R <20 was chosen as the differentiating criterion because R = 20 is a value slightly larger than the largest Rm value occurring in SC00-25 (18.6 for SC02) and is a value larger than that believed to have been experienced during the Maunder minimum (cf. Wilson 1988; Beer, Tobias and Weiss 1998; Hathaway and Wilson 2004; Kovaltsov, Usoskin and Mursula 2004; Hathaway 2015; Usoskin 2017.)

Table 1. N(R < 20), Rm, RM, ASC and PER for SC00-25

SC	N(R<20)	Rm	RM	ASC	PER
00	–	–	158.9	–	–
01	21	14	144.1	75	135
02	3	18.6	193	39	108
03	15	12	264.3	35	111
04	11	15.9	235.3	41	163
05	44	5.3	82	82	147
06	72	0	81.2	70	154
07	50	0/2	119.2	78	126
08	16	12.2	244.9	40	116
09	4	17.6	219.9	55	149
10	22	6	186.2	50	135
11	13	9.9	234	41	141
12	27	3.7	124.4	60	135
13	35	8.3	146.5	46	142
14	42	4.5	107.1	49	138
15	42	2.5	175.7	49	121
16	18	9.4	130.2	56	121
17	24	5.8	198.6	43	125
18	11	12.9	218.7	39	122
19	18	5.1	285	47	126
20	13	14.3	156.6	49	137
21	6	17.8	232.9	45	126
22	19	13.5	212.5	38	119
23	19	11.2	180.3	63	148
24	39	2.2	116.4	64	132
25	43	1.8	–	–	–
	25	9	177.7	52	132
Mean					
sd	17	5.8	56.8	14	14
Median	19	9.4	175.7	49	133.5
na	14	13	13	13	12
nb	11	12	12	11	12
Ra	6	6	4	7	5
z	–0.57	–.06	–2.17	0.4	–1.2
N(R<20) <19 months					
	11.6	13.2	219.5	44.3	129.1
Mean					
sd	5.3	4.1	45	6.8	16.8
n	11	11	11	11	11
N(R<20) ≥19 months					
	35.6	5.6	144.2	59	135.2
Mean					
sd	15	4.6	43.5	14.3	10.7
n	14	14	13	13	13
t	–5.05	4.3	4.16	–3.12	–1.08

Notes:

SC means sunspot cycle
N(R<20) is the number of contiguous months bounding Rm with R<20
Rm is sunspot minimum amplitude using smoothed monthly mean sunspot number R
RM is sunspot maximum amplitude using smoothed monthly mean sunspot number R
ASC is the ascent period in months from Rm occurrence to RM occurrence
PER is the period or length of SC in months from Rm occurrence SCn to Rm occurrence SCn+1
na is the number of entries above the median
nb is the number of entries below the median
Ra is the number of runs of na
z is the normal deviate for the sample
sd is the standard deviation
n is the number of entries
t is the t statistic for independent samples

Similarly, Table 2 gives the mean, sd and median for the entire grouping (SC01-24) and the two subgroups based on the median value of N(R<20) = 20.3, as well as the results of runs testing for randomness but now using 2-cma values.

Table 2. 2-cma of N(R < 20), Rm, RM, ASC and PER for SC01-24

SC	N(R<20)	Rm	RM	ASC	PER
01	–	–	160	–	–
02	10.5	15.8	198.6	47	115.5
03	11	14.6	239.2	37.5	123.3
04	20.3	12.3	204.2	49.8	146
05	42.8	6.6	120.1	68.8	152.8
06	59.5	1.4	90.9	75	145.3
07	47	3.2	141.1	66.4	130.5
08	21.5	10.6	207.2	53.3	126.8
09	11.5	13.4	217.7	50	137.3
10	15.3	9.9	206.6	49	140
11	18.8	7.4	194.7	48	138
12	25.5	6.4	157.3	51.8	138.3
13	34.8	6.2	131.1	50.3	139.3
14	40.3	5	134.1	D48.3	134.8
15	36	4.7	147.2	50.8	125.3
16	25.5	6.8	158.7	51	122
17	19.3	8.5	186.5	45.3	123.3
18	16	9.2	230.3	42	123.8
19	15	9.4	236.3	45.5	127.8
20	12.5	12.9	207.8	47.5	131.5
21	11	15.9	208.7	44.3	127
22	15.8	14	209.6	46	128
23	24	14.5	172.4	57	136.8
24	35	4.4	–	–	–
25	–	–	–	–	–
	24.7	9.8	180.9	51.1	132.4
Mean					
sd	13.4	4	40.3	8.8	9.2
Median	20.3	9.2	194.7	49.4	131
na	12	12	12	11	11
nb	11	11	11	11	11
Ra	3	3	3	4	4
z	–2.67	–2.67	–2.67	–1.67	–1.67
N(R<20) <20.3					
	14.2	11.9	212.4	45.6	128.7
Mean					
sd	3.1	3.1	17	3.5	7.5
n	11	11	11	11	11
N(R<20) ≥20.3					
	34.4	6.8	151.3	56.6	136.2
Mean					
sd	11.8	3.8	34.5	9.2	9.6
n	12	12	11	11	11
t	–5.5	3.51	5.27	–3.71	–2.04

Notes:
SC means sunspot cycle
N(R<20) is the number of contiguous months bounding Rm with R<20
Rm is sunspot minimum amplitude using smoothed monthly mean sunspot number R
RM is sunspot maximum amplitude using smoothed monthly mean sunspot number R
ASC is the ascent period in months from Rm occurrence to RM occurrence
PER is the period or length of SC in months from Rm occurrence SCn to Rm occurrence SCn+1
sd is the standard deviation
na is the number of entries above the median
nb is the number of entries below the median
Ra is the number of runs of na
z is the normal deviate for the sample
n is the number of entries
t is the t statistic for independent samples

From Table 1, one finds that the two subgroupings based on N(R<20) have means that are statistically independent at $\alpha = 0.05$ or higher level of statistical significance for all parameters, except PER. Hence, if one knows the value of N(R<20), one can simply estimate each of the parameters for that particular cycle. Because N(R<20) = 43 for SC25, one predicts SC25 to have Rm = 5.6 ± 4.6, RM = 144.2 ± 43.5, ASC = 59 ± 14 months and PER = 132 ± 14 months. (For SC25, Rm = 1.8 was observed in December 2019.)

From Table 2, one finds that the variance using 2-cma for each of the parameters is greatly reduced (50% or more), as compared to using the observed cyclic values. For all parameters the t statistic for independent samples is statistically significant at $\alpha = 0.05$ or higher.

Figures 1 and 2 display the cyclic variation (thin line) and 2-cma (thick line) of N(R<20), Rm, RM, ASC and PER. All parameters show large variations, both above and below their respective median values, with each variation lasting typically 3 or more consecutive cycles, easily discerned using the 2-cma values. For example, Figure 1(a) shows the variation in N(R<20). Discernable are large variations above R = 19 between SC05-07, SC13-15 and what appears to be another one beginning with SC24. These periods of larger than median value have previously been associated with extended periods of reduced sunspot number associated with the Dalton minimum (SC05-07) and the minimum near the beginning of the 20th Century (SC13-15). Plainly, large values of N(R<20) are associated with smaller values of Rm (Figure 1(b)) and RM (Figure 1(c)), while small values of N(R<20) are associated with large values of Rm and RM (i.e., sunspot number amplitude varies inversely with N(R<20)). Such behavior is less apparent in ASC (Figure 2(a)) and PER (Figure 2(b)).

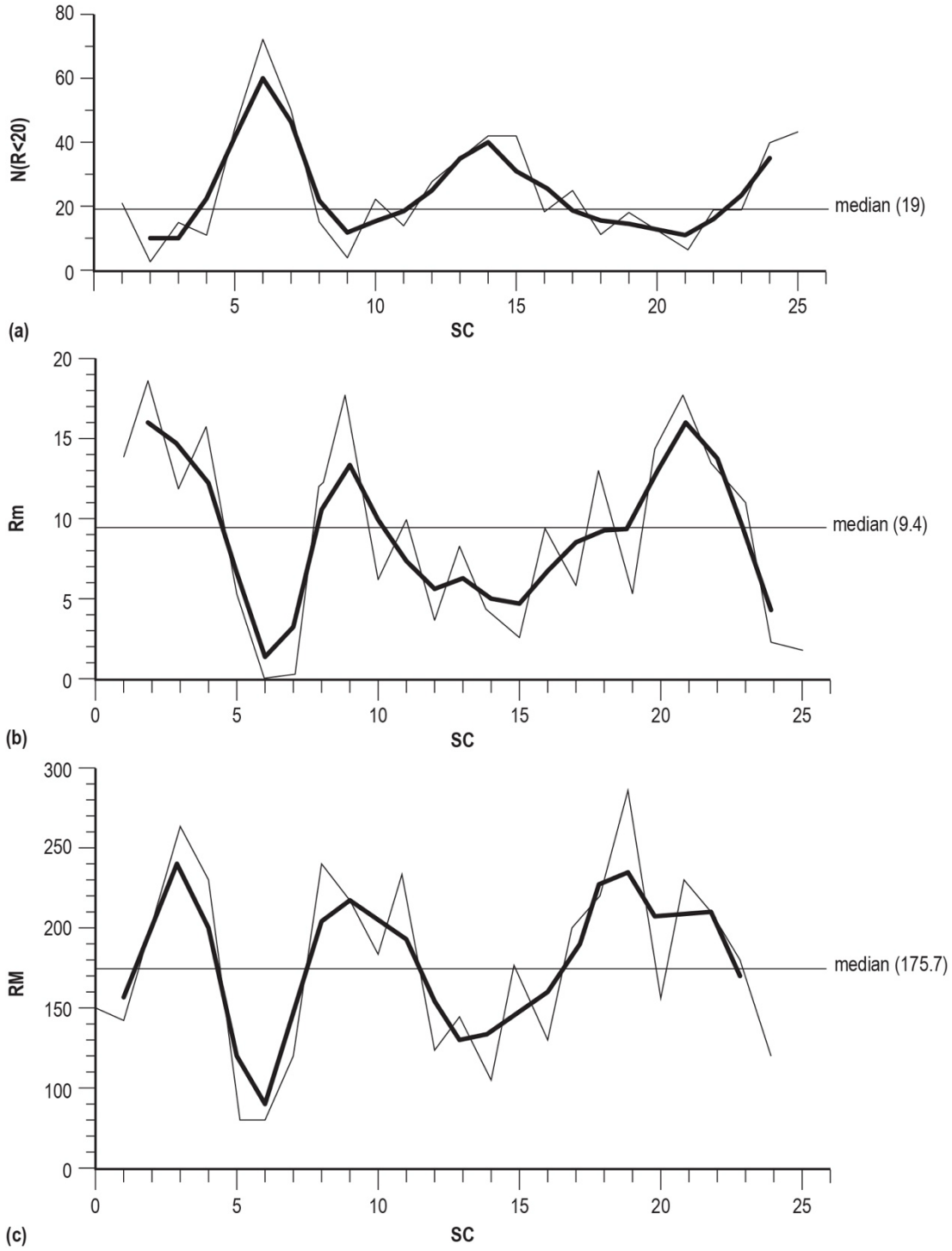

Figure 1. (a) The variation of N(R< 20) for SC00-25; (b) the variation of Rm for SC01-25; and (c) the variation of RM for SC00-24. The medians are shown (19, 9.4 and 175.7, respectively). The thin line is the actual cyclic value, and the thick line is the 2-cma.

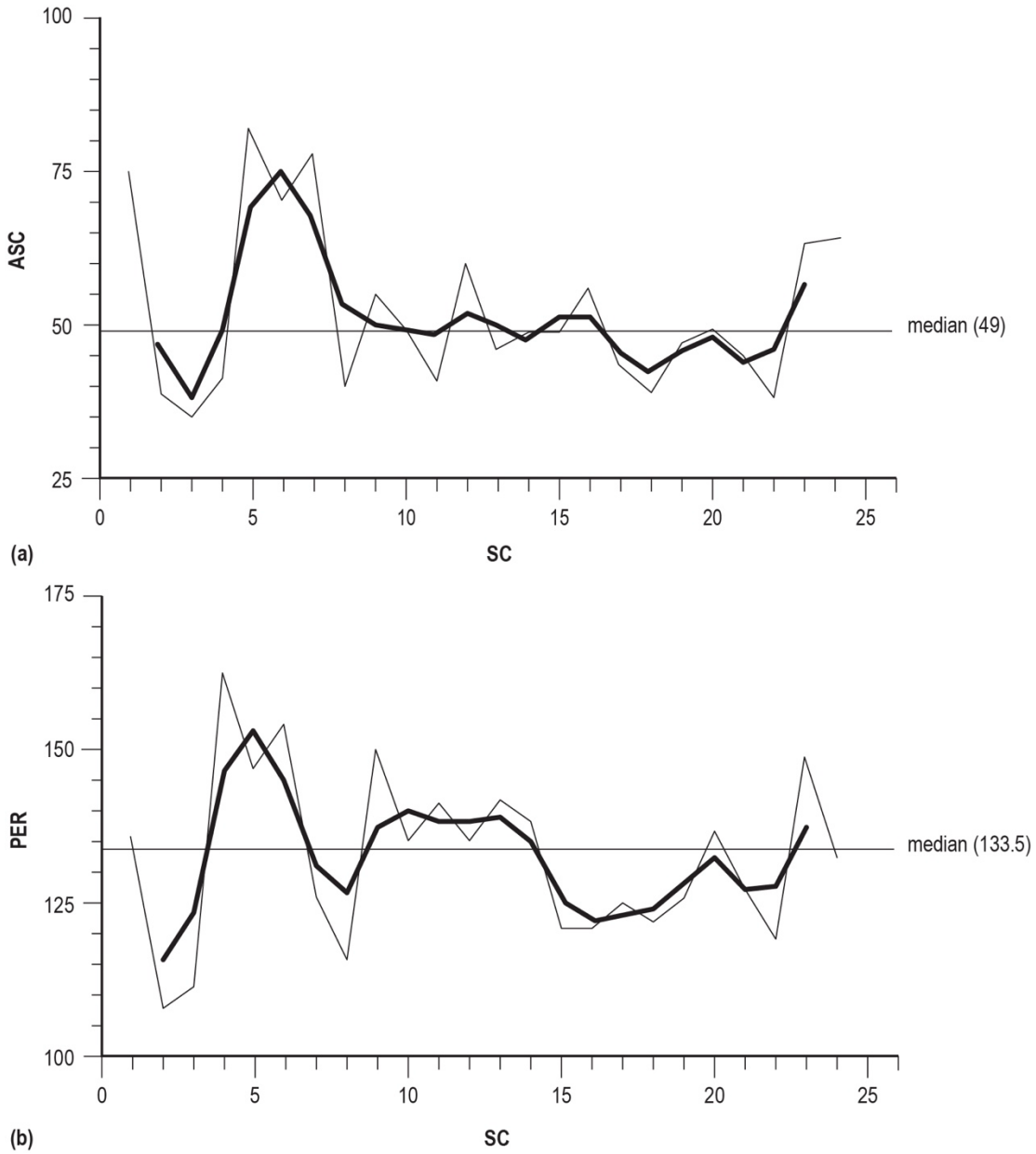

Figure 2. (a) The variation of ASC for SC01-24; and (b) the variation of PER for SC01-24. The medians are shown (49 and 133.5, respectively). The thin line is the actual cyclic value, and the thick line is the 2-cma.

Figure 3 depicts the scatterplots of Rm, RM, ASC and PER versus N(R<20). In each of the plots the inferred regression line is shown and various statistics are given, including the inferred regression equation *y*, the inferred correlation coefficient *r*, the inferred coefficient of determination r^2 (a measure of the amount of variance explained by the independent variable *x*), the inferred standard error of estimate S_{yx} and the inferred *t* statistic for evaluating the statistical significance of the slope in the regression equation. Also given is the result of Fisher's exact test for 2×2 contingency tables (determined using the median values of the parameters, the thin

vertical and horizontal lines), where P_o is the probability of obtaining the observed result and P is the probability of obtaining, not only the observed 2×2 table, but also those that are more suggestive of a departure from independence (chance). The tiny downward pointing arrow in Figure 3(b), (c) and (d) at N(R<20) = 43 is the known value of N(R<20) for SC25.

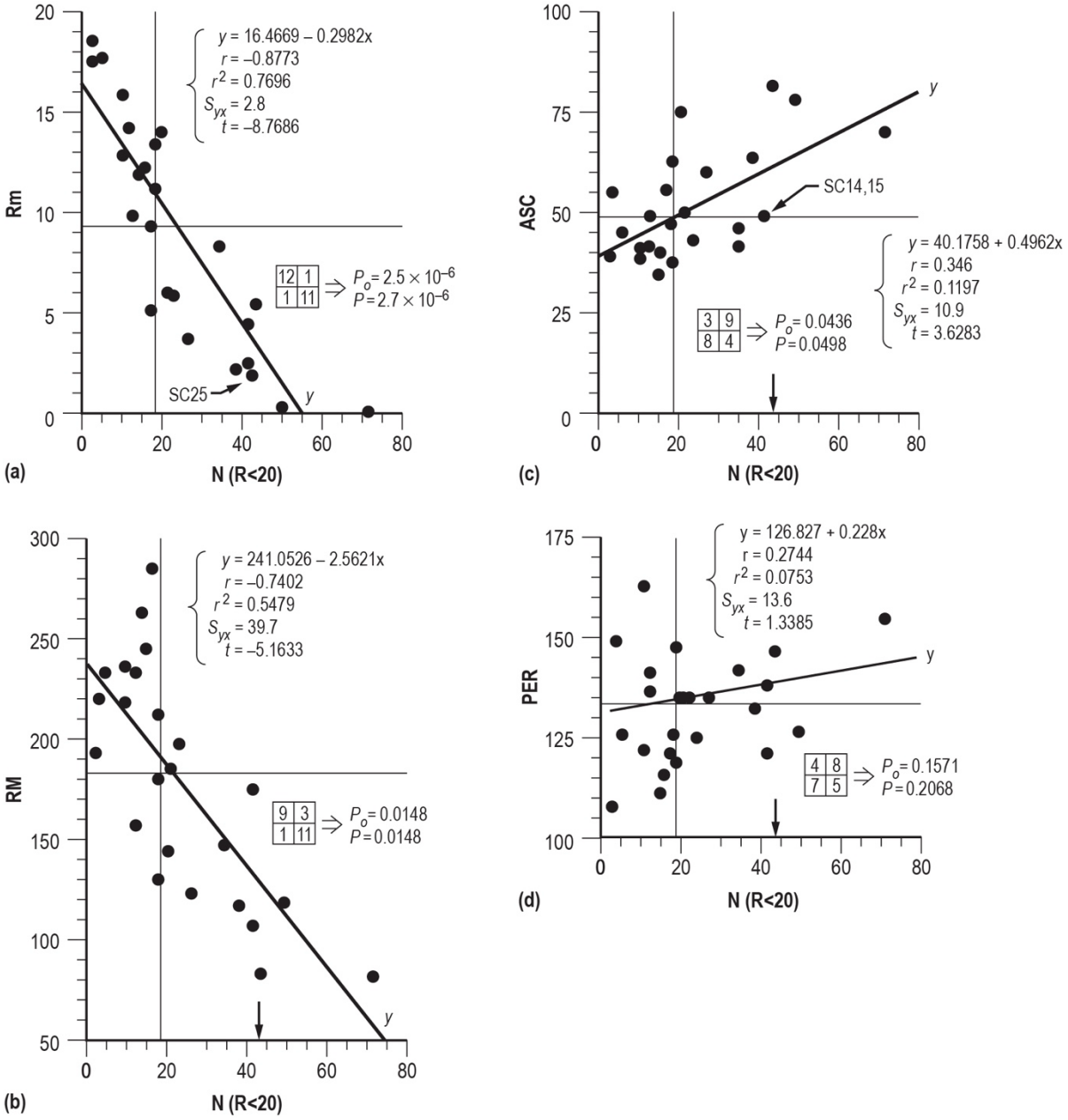

Figure 3. Scatterplots of (a) Rm versus N(<20); (b) RM versus N(R<20); (c) ASC versus N(R<20); and (d) PER versus N(R<20). Results of statistical analyses are given. The small arrow at N(R<20) = 43 is the value for SC25.

Figure 3(a) depicts the scatterplot of Rm versus N(R<20). A strong inverse relationship is shown (as expected). The larger (or smaller) the value of N(R<20), the smaller (or larger) the inferred Rm. The inferred regression equation has $r = –0.8773$ and $r^2 = 0.7696$, meaning that about 77% of the variance in Rm can be explained by the observed variation of N(R<20). Also, $S_{yx} = 2.8$ and $t = –8.7686$, inferring a highly statistically significant result. Because N(R<20) = 43 for SC25, one infers Rm = 3.6 ± 2.8 (the ±1 sigma prediction interval) for SC25. Based on Fisher's exact test, $P = 2.7\times10^{-6}$, inferring a highly statistically significant result. Hence, once N(R<20) >19, it became apparent that Rm would be <9.4 for SC25, which occurred nine months prior to SC25's observed Rm occurrence, being 1.8 in December 2019.

Figure 3(b) displays the scatterplot of RM versus N(R<20). Like Rm versus N(R<20), it too shows a statistically important inverse relationship to exist between RM and N(R<20). Because N(R<20) = 43 for SC25, one computes RM = 130.9 ± 39.7, inferring that RM for SC25 very probably will lie in the lower-right quadrant of the scatterplot.

Figure 3(c) shows the scatterplot of ASC versus N(R<20). Unlike the scatterplots of Rm versus N(R<20) and RM versus N(R<20), the scatterplot of ASC versus N(R<20) is positively correlated. This is because ASC is known to be inversely correlated against RM (i.e., the Waldmeier Effect; cf. Wilson 2015, 2019; Hathaway 2015). Because N(R<20) = 43 for SC25, one estimates ASC = 62 ± 11 months based on the statistically important inferred regression equation, suggesting that it likely will lie in the upper-right quadrant (i.e., ASC ≥49 months), inferring RM occurrence for SC25 on or after January 2024 (and prior to January 2026).

Figure 3(d) depicts the scatterplot of PER versus N(R<20). Of the four scatterplots, this one is the weakest. The scatterplot appears to be randomly distributed with only a slight tendency to associate longer PER with large N(R <20) and shorter PER with small N(R <20). Because N(R<20) = 43 for SC25, one estimates PER = 137 ± 14 months, or Rm occurrence for SC26 in May 2030 ± 14 months (prior to July 2031).

Because R for SC25 surpassed SC24's RM (116.4) in February 2023 (expected from the Even-Odd inferred relationship; Wilson 2015), it is now established that SC25 is not smaller in RM as compared to that of SC24, as often had been suggested. Based on the PER of SC24 (132 months), one projects SC25's RM = 181.4 ± 42.6 (cf. Wilson 2015, 2019). Similarly, based on SC25's Rm (1.8), one projects its RM = 136.5 ± 49.1 (Wilson 2015). Based on the minimum values of the geomagnetic indices in the vicinity of Rm (which occurred five months after the Rm occurrence), one projects SC25's RM = 157.6 ± 29.0 (based on Aam = 10.9) and 136.0 ± 26.8 (based on Apm = 5.0). Lastly, as gleaned from this study, based on SC25's N(R<20) = 43 months, one expects SC25's RM = 130.9 ± 39.7. Together, the mean of the five predictions is 148.5 ± 21.1. Assuming SC25 will have RM = 148.5, the 2-cma for SC24 will be 140.4, some 32 units of sunspot number below SC23's value, strongly suggesting that SC24, indeed, marks the beginning of yet another extended interval of low sunspot number minimums and maximums that should persist, at least, through SC26 (and possibly longer; cf. Rigozo, Souza Echer, Evangelista et. al. 2011; Bisoi, Janardhan and Ananthakrishnan 2020).

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MINUTES OF THE
ALABAMA ACADEMY OF SCIENCE
Executive Committee Meeting
Held via Zoom and at Samford University 10/7/2023 8:00 AM CST

Meeting was called to order by Jack Shelley-Tremblay

Those in attendance were:
Jack Shelley-Tremblay
Bettina Riley
Ellen Buckner
Shaoyang Liu
Larry Krannich
Denis Sansom
Adriane Ludwick
Stephen Royal Slauson
Mark Caulkins
Mark Sciuchetti
Matthew Edwards
Adriane Ludwick
Donna Perygin
Jean-Pierre Arditi
Vinoy Thomas
Byunghoon Lee
Ken Marion
Donna Streeter
Mohit Anand
Jeff Morris
Doug Marshall
Kathryn Catlin
Heejoon Park
Matthew Edwards
Mary Lou Ewald
Malia Fincher

The meeting began with an introduction of the officers of the AAS. Jeff Morris called the meeting to order at 8:10 AM. The meeting minutes from the spring 2023 meeting were reviewed and an addendum was added to March 4, 2023. Jeff Morris moved to approve the minutes and Matthew Edwards seconded. The motion passed.
Jeff Morris navigated through the agenda for the meeting as posted:
1. The following nominations were discussed: Jean-Pierre Arditi, (At-large graduate student), Reagan Thomas, At-large member. Jack Shelley-Tremblay moved to add these candidates to the election slate and push an election to the general membership and Ellen Buckner seconded the motion. The motion passed.
2. 2024 Meeting JSU: Price Registration.
a) Call for Abstracts opens Oct 15, 2023, and closes January 15. Gorgas competition papers

are due December 19, 2023.
b) Donna Perygin presented the estimated costs for lunch and banquet meals at the spring 2024 meeting. Lunch is $12.99 and the banquet will be 21.99 per person.
c) A reusable water bottle will be included in the registration bag. A $10-$12 increase in price for registration may be necessary to cover costs.
d) The “101” logo for the meeting was presented.
e) The registration portal will also open Oct 15, 2023.
f) Hotel block will be available at the Hampton Inn at the rate of $114 per night. Please register early, because not many rooms are available. Contact Harry Arcy and mention the name of the meeting as “JSU chemistry conference.
” The Gamecock Inn has also been
recently renovated and is more affordable. A list of all local hotels will be added to theconference page.
g) Parking permits will be provided in some form.
h) Poster display boards will be provided by the university.
i) Dr. Walter Ingram from NOAA will be the keynote speaker. Luncheon speakers are also being considered.
j) Please add an * to designate women in stem in the program listing. People should self-select to participate when they submit an abstract. We will create a special award for student presentations in this category.
k) Jeff Morris moved to approve, and Dr Marshall seconded a motion to approve the report from the local arrangements committee.
3. SeeIt Productions: 100th Anniversary Committee, Staśi Bara requests an additional $5,000 to finish the film. 100th Anniversary Committee recommends the need for a draft outline of the finished product prior to payment of $2500 payable immediately, and another $2500 payable upon completion to finish film develop a long and short version of the film. Dr. Morris moved to accept this proposal and Dr Buckner seconded. The motion was approved.
4. 5. Dr. Ellen Buckner gave an update on the 100th anniversary meeting.
Motion to nominate Greg Schmidt Archivist from Auburn University as archivist for the AAS. Dr. Morris moved and Dr. Edwards seconded. The motion was approved.
6. The potential list of nominations and those interested in service was presented by Dr. Shelley-
Tremblay. Please send all nominations to Dr. Edwards by February 1, 2024, for next year.
7. Update on Funding, Alabama Space Grant. Dr. Thomas and Mitzi Adams should be added to the
Space Grant. Dr. Shelley-Tremblay addressed the possibility of creating travel funding for universities that have not been participating in the AAS annual meeting.
8. Newsletter Discussion: Jeffrey Morris presented the idea to create an ongoing newsletter. This
is a good place to advertise job opportunities, publications, and books. Also, it could feature news about programs, etc. If possible, he will continue numbering with the previous newsletters, although these do not seem to be available.
9. Journal update: the 2023 journal issue should be published soon. Any members who would liketo help with the journal are welcomed and encouraged to participate in soliciting submissions or editorial tasks. Dr. Thomas and Dr. Edwards also proposed that we feature descriptions of the educational activities of funded programs, centers, and projects in the AAS Journal.
10. We need meeting host volunteers for 2027 and 2028. Please contact Dr. Shelley-Tremblay.
11. 2025 Meeting: Troy University

12. The Alabama Science Trail Patch system developed by Mel Blake was presented by Dr. Shelley-
Tremblay. A Boy Scout Patch is available for completing visits to 10 sites.
13. 14. 15. A jobs board has been added to the AAS site.
Dr. Shelley-Tremblay please call Brian about the Log In button on the website.
John-Piere Arditi suggested that we hold a three-minute thesis section at the annual meeting. He will check with the 3MT organization to determine whether we can hold one, and whether we could host the state finals for their organization.
The section and officer reports were presented:
• Dr. Thomas highlighted the importance of connecting with industry for submissions, sponsorships, and networking.
• Dr. Buckner suggested that we have a committee on industry relations. Dr. Shelley-Tremblay amended that suggestion to suggest that the electronic media committee take on that charge.
• Dr. Buckner asked Dr. Edwards about creating a list of contacts at HBCUs around the state.Dr. Edwards will update once complete.
• Mark Jones provided and update on AJAS and enhancing participation by Title I schools. Observers from last year's meeting will hopefully come as participants in this year's meeting, and this funding can continue for one more year. Continuing fund past that will be sought in the SPACE Grant. Last year's budget changed so that the grant would no longer cover an iPad and a desktop computer. He requested to be reimbursed for the desktop from the AJAS Funds. Mark Jones made a motion to be reimbursed approx. $545 for a desktop computer to be used for AJAS. The motion was seconded by Mark Caulkins. The motion was approved. Mark also requested access to Adobe Writer so that he can edit PDFs.
• Mary Lou Ewald provided an update on the AL STEM Council, which approached state legislators about funding YouTeach to build the STEM teaching pool in AL. There is a shortage of STEM teachers in Alabama at the moment. Perygin will work with Jones to contact the WIS group.
• Please promote your local or regional Science Olympiad. Alumni who are now college students can be very valuable in helping to run tournaments. There are small stipends available for teachers to help run a team. The academy will draft a position paper and try to help secure for providing support to Science Olympiad and AJAS teacher mentors.
• The TEAMS program requires service/continuing education for their teachers, and they can meet those requirements through AJAS and Science Olympiad. Mary Lou Ewald, Mark Jones, and Jack Shelley-Tremblay will follow up on this.
• Dr Heejoon Park addressed the efforts of his section to recruit more participants from his university. Dr Shelley-Tremblay will provide some communication templates to help with this.
• Dr. Vinoy Thomas addressed the materials science special section at the last annual meeting and the possibility of continuing that section at the meeting.
• Dr Mark Caulkins addressed the difficulty of finding sufficient judges.
• Malia Fincher raised concerns about the shortness of the poster sessions at the last annual meeting. Ellen Buckner suggested that we extend the length of the session for judged posters. Also, Dr Shelley Tremblay can provide training and instruction to section chairs and vice chairs before the annual meeting.
• A question will be added to the registration form asking if faculty members are willing to judge presentations or posters. Dr. Shelley-Tremblay will make this change to the online registration.
• Malia Fincher requested that the students be able to receive feedback on judging, if possible.

Entering the student email address into the judging form would enable the student to receive an automated email. Asking students to add QR codes to their poster linking to their email address would help with this.

• Budget discussion: Ken Marion provided a report for the Budget and Finance Committee, indicating that the senior committee balance is higher than usual. The Gorgas Program Fund is approx. $260,000, down about $20,000 from the spring meeting as a result of withdrawals and a lazy market with little growth this year. There may be further decline this year. A meeting of the investment committee for Gorgas with Jim Sumter is needed near the end of this year or the beginning of 2024 to consider altering the portfolio. We are withdrawingfaster than we are accruing, so we need industry partners or government partners to grow this account.

• Bettina Riley presented the Income and Expense Report, indicating that the annual meeting generated an unusually large amount of income, but also had higher than usual expenses. The amount of dues also increased in volume. Our only income sources are the annual meeting and dues. The annual meeting revenue supports the annual expenses of the academy. We can probably afford the $5000 to pay for the AAS video that is under production.

• Dr. Shelley-Tremblay presented the call for papers for the Spring 2024 AAS Meeting, Jeff Morris moved to approve the call for papers, and Dr. Fincher seconded. The motion was approved.

• Dr. Shelley-Tremblay presented a motion to hold the student registration fees constant from last year, and increase the professional registration fee from $130 to $155. Bettina Riley seconded the motion. The motion was approved.

• Dr. Brian Burnes will be requested to write a letter of appreciation to Samford University and Dr. Ellen Buckner for hosting the 100th anniversary AAS meeting.

• Please consider nominating colleagues for awards through our AAS website.

Dr. Morris motioned and Dr. Edwards seconded to adjourn the meeting. The meeting adjourned at 10:55 AM.

Alabama Academy of Science Journal

Scope of the Journal:

The Alabama Academy of Science publishes significant, innovative research of interest to a wide audience of scientists in all areas. Papers should have a broad appeal, and particularly welcome will be studies that break new ground or advance our scientific understanding.

Information for the Authors:

- Manuscript layout should follow the specific guidelines of the journal.
- The authors are encouraged to contact the editor (E-mail: brtoone@samford.edu) prior to paper submission to obtain the guidelines for the author.
- At least one author must be a member of the *Alabama Academy of Science* (except for Special Papers).
- The author(s) should provide the names and addresses of at least two potential reviewers.
- Assemble the manuscript in the following order: Title Page, Abstract Page, Text, Brief acknowledgments (if needed), Literature Cited, Figure Legends, Tables, Figures.

Review Procedure and Policy:

Manuscripts will be reviewed by experts in the research area. Manuscripts receiving favorable reviews will be tentatively accepted. Copies of the reviewers' comments (and reviewer-annotated files of the manuscript, if any) will be returned to the correspondent author for any necessary revisions. The final revision and electronic copy are then submitted to the *Alabama Academy of Science Journal* Editor. The author is required to pay $100 for partial coverage of printing costs of the article.