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Is There Beauty in Physics?

For the scientific layman, it is often a surprise to pick up a book or read an article written by a physicist and find a lot of talk about the beauty of physics. The general attitude regarding science is that it is cold and logical, based only on fact and experiment, expressed strictly in mathematical terms. So, appeals to aesthetics come as a bit of a shock. The average reader, as well as the philosopher and the physicist himself, would be more than justified in asking what exactly does the physicist mean when he talks about the beauty of physics. The philosopher, of course, upon learning what the physicist means when he calls physics beautiful must then press the question: Is it true that physics is beautiful? Or, more precisely: Are the theories and equations identified as beautiful actually beautiful? The physicist and the layman should also be interested in this question, but, lacking training in the appropriate field, they most likely don’t know how to frame the question or even ask it at all. More often than not, the layman is likely to pass off the question as strangely sentimental or irrelevant or else regard the beauty of physics as some secret and mysterious, perhaps even mystical, knowledge that justifies new age spirituality.

This paper takes the position of the philosopher who wants to know, first of all, what exactly is it that the physicist means when he calls physics or particular theories and equations beautiful. The physi-

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cist, after all, may be saying nothing more than that he has a taste for that particular subject or that the equations happen to please him in some esoteric way. If that were the case, the study would be one more for the psychologist than the philosopher. If, however, the physicist intends to be making a true statement about the reality of beauty, then it is a matter of metaphysics, and the philosopher is back in business.

Once the meaning of the statement has been established, the task at hand is to determine whether or not the intended meaning is true or false: Is physics actually beautiful? Are there theories and equations which, in reality, measure up to some universal standard of beauty? More fundamentally, what is the nature of beauty, the standard to which the physics is being held up? Is beauty real in the first place? In short: Is there beauty in physics? This is the question this paper seeks to answer.

Here is an outline of the procedure. First and foremost, after looking at the testimony of scientists, the domain of study must be marked off. On which playing field are these questions appropriately addressed? When discussing the nature and beauty of physics, are we doing physics, science, psychology, or philosophy? To answer this question, it must be answered, what is the nature of physics? Secondly, what is the nature of beauty? Lastly, does the meaning of the physicists' acclamations actually line up with the true nature of beauty? The reader ought to know that this paper concludes in the affirmative.

The Testimony

When we turn to the world of physics literature to look for quotes and examples of claims regarding beauty in physics, we stumble upon an embarrassment of riches. Put simply, there are many, many available quotes from physicists, mathematicians, philosophers and historians of science claiming beauty in physics. In fact, many even hold that beauty

is not just found in physics, but is in fact a standard for truth, as shocking as that may sound. It is not necessary to present all of the available quotations about beauty from physicists, but it is necessary to examine some of them. These quotes will also be helpful because, interestingly, the physicists who identify what is beautiful in physics manage to identify some of the key aspects of beauty from a traditional philosophical approach.

To begin with, Richard Feynman, an influential physicist of the 20th century, writes in *The Character of Physical Law*, “You can recognize truth by its beauty and simplicity.”¹ This statement is important because it is immediately evident that Feynman is holding up beauty as a standard for truth in physics, and he also, perhaps unwittingly, identifies a characteristic of beauty: simplicity.

Werner Heisenberg, another eminent 20th century physicist, writes that beauty “in exact science, no less than in the arts . . . is the most important source of illumination and clarity.”² Like Feynman, Heisenberg appeals to beauty as a standard of truth, and he identifies another characteristic of beauty: clarity. Heisenberg explains one of the reasons quantum theory was found convincing: its beauty.³

Erwin Schrödinger makes a similar statement regarding Einstein’s theory of General Relativity, this time in relation to its discovery: “Einstein’s marvellous theory of gravitation . . . could only be discovered by a genius with a strong feeling for the simplicity and beauty of ideas.”⁴ Schrödinger calls Einstein’s theory of general relativity *mar-*

¹ Richard Feynman, *The Character of Physical Law* (Cambridge, Mass.: The M.I.T. Press, 1992), 171.

² Quoted in Robert Augros and George Stanciu, *The New Story of Science* (Chicago: Gateway Editions, 1984), 39.

³ *Ibid.*

⁴ Quoted in *ibid.*

vellous, and he appeals to the simplicity and beauty of ideas. This same characteristic of simplicity was identified by Feynman.

Paul Dirac, another important modern physicist, made the claim that, “It is more important to have beauty in one’s equations than to have them fit experiment.”⁵ This is a bold statement, but one that unequivocally claims, not only that beauty is in physics, but that beauty is of eminent importance.

Roger Penrose, theoretical physicist and mathematician, writes, “Aesthetic criteria are enormously valuable in forming our judgments . . . A beautiful idea has a much greater chance of being a correct idea than an ugly one.”⁶ When writing about the judgments *we* form, he is speaking as a theoretical physicist. He is stating without equivocation that beauty plays a role in how physicists develop their theories.

Brian Greene, a contemporary theoretical physicist, writes in his book *The Elegant Universe*,

It is certainly the case that some decisions made by theoretical physicists are founded upon an aesthetic sense—a sense of which theories have an elegance and beauty of structure on par with the world we experience . . . especially as we enter an era in which our theories describe realms of the universe that are increasingly difficult to probe experimentally, physicists do rely on such an aesthetic to help them steer clear of blind alleys and dead-end roads that they might otherwise pursue. So far, this approach has provided a powerful and insightful guide.⁷

For the sake of being just to Brian Greene, he clarifies that he does not believe beauty to be an infallible guide to truth, but he does acknowledge that there is beauty in physics and that it has played an instrumental role so far.

⁵ Quoted in *ibid.*

⁶ Roger Penrose, *The Emperor’s New Mind* (New York, N.Y.: Oxford University Press, 1999), 544.

⁷ Brian Greene, *The Elegant Universe* (New York, N.Y.: W.W. Norton & Company, Inc., 2003), 167.

The role of beauty described by these physicists has historical support. In 1958 Richard Feynman and Murray Gell-Mann proposed a new theory of the subatomic weak interaction. Even though it contradicted nine experiments, Feynman and Gell-Mann argued for it on the basis of its beauty. Gell-Mann writes, “When you have something simple that agrees with all the rest of physics and really seems to explain what’s going on, a few experimental data against it are no objection whatever. Almost certain to be wrong.”⁸ And they were. Gell-Mann identifies the three aspects of beauty in his statement: simplicity, harmony (agreement with the rest of physics), and clarity (seems to explain what’s going on).

The quotes cited so far primarily deal with theoretical physics, but there is even beauty in experiment. Historian of science George Johnson, in his book entitled *The Ten Most Beautiful Experiments*, writes regarding his selection of the ten particular experiments discussed in the book,

These experiments were designed and conducted with such a straightforward elegance that they deserve to be called beautiful. This is beauty in the classical sense—the logical simplicity of the apparatus, like the logical simplicity of the analysis, seems as pure and inevitable as the lines of a Greek statue. Confusion and ambiguity are momentarily swept aside and something new about nature leaps into view.⁹

Johnson appeals to the classical sense of beauty, the sense that will be employed in this paper, and he points out the characteristics of simplicity and the clarity of revelation.

Quotes upon quotes could be added to this collection, but the witnesses that have gone before should suffice to demonstrate that physicists certainly claim beauty’s presence in physics and then more: they

⁸ Quoted in Augros and Stanciu, *The New Story of Science*, 41.

⁹ George Johnson, *The Ten Most Beautiful Experiments* (New York, N.Y.: Vintage Books, 2008), xi–xii.

seat it upon a judgment chair to be an arbiter of truth. A question for further study might ask whether or not physicists are “doing physics” when they appeal to beauty, or are they straying into the territory of a different subject? The passages presented so far also identify aspects of beauty that will be lined up with the traditional understanding of beauty: simplicity, harmony, and clarity. There can be no question about whether physicists claim there is beauty in physics. It is now time to begin the investigation regarding the truth of this claim.

Proper Genus

First things first. Small mistakes at the beginning result in large mistakes in the end, as much modern philosophy has demonstrated.¹⁰ This paper has a specific question, and it is necessary at the beginning to discover what species of question it is. In other words, does the question belong properly to the study of science, philosophy, or psychology? While many scientists speak often about the beauty of physics, are they speaking as scientists, philosophers, or beings possessed of a psyche?

One of these three options should be eliminated from the start. As is evident from the data of the personal testimony of scientists, assertions about the beauty of physics are not efforts to explain how the scientist feels. Indeed, there are feelings and other psychological effects, but statements about beauty posit something real in the real world. Beauty is something that is actually, somehow, present in physics itself. If it turns out, after this investigation, that beauty does not really exist in physics, or perhaps does not exist as a reality at all, then a psychological analysis of physicists is in order to find out the insanity

¹⁰ See Étienne Gilson, *The Unity of Philosophical Experience* (San Francisco, Calif.: Ignatius Press, 1999), and, for a more “layman oriented treatment” of the subject, Mortimer J. Adler, *Ten Philosophical Mistakes* (New York, N.Y.: Collier Books, 1987).

from which they suffer, but it should be clear that the first order of business is not one of mere psychology.

Physicist George Stanciu and philosopher Robert Augros write, “The beauty physicists seek is not the product of private or idiosyncratic emotion.” The physicists even identify consistent characteristics of beauty, as described above. They ascribe the beauty and those characteristics to nature itself, not merely to their own reactions or emotions.¹¹ It is clear that the question of beauty in physics is not initially one of mere psychology.

So, is the question one of physics or philosophy? While both physics and philosophy have a common origin, the division between them was delineated as early as the Ancient Greeks, though the terminology is slightly different. What we call today *physics* often bears the same name, but what we have been here calling *philosophy* has been called *metaphysics* and sometimes *theology*. In book VI of his *Metaphysics*, Aristotle says that math, physics, and metaphysics are all speculative sciences. In other words, they seek to know for the sake of knowing. They are not practical or productive sciences. Their end is simply to know. He also describes the differences among the sciences: mathematics, physics, and metaphysics.¹² Essentially, each science is separated from the other according to the level of abstraction. Physics seeks to know about the changes that occur in things and the causes of their motion. Mathematics seeks to know through the immaterial means of reasoning about limited quantities which exist in the changing world of nature. Philosophy seeks to know about what is unchangeable and eternal.

¹¹ Augros and Stanciu, *The New Story of Science*, 41–42.

¹² Aristotle, *Metaphysics*, 1026a, trans. Hugh Tredennick. Available online—see the section *References* for details.

Ptolemy agrees with Aristotle's division of the sciences,¹³ and Thomas Aquinas takes up a quite detailed analysis of the topic in the section of his Commentary on the *De Trinitate* of Boethius often called "On the Division of the Sciences."¹⁴ Aquinas refers to both Aristotle and Ptolemy and agrees with them. Physics studies what depends on matter for its being and for its being understood. Mathematics studies what depends on matter for its being but not for its being understood.¹⁵ In other words, physics studies the motion of matter and must study material things for the motion to be known. Experiment is a necessary part of physics. Mathematics studies limited quantity which exists in matter but can be investigated apart from matter. A mathematician can do his work with nothing but a pencil and paper. He does not have to be concretely handling what it is he studies. Metaphysics, on the other hand, deals with objects of knowledge which do not depend on matter for existence nor must they be known through matter.

This analysis of Thomas Aquinas is helpful. It sheds more light on what Aristotle meant by what is mutable and immutable. Things of matter are mutable, and so physics uses what is mutable (concrete material things) to study what is mutable. Philosophy studies first principles and causes, which are immaterial. As with all the sciences, Aristotle and Aquinas agree that we begin with the senses and abstract from them, but philosophy deals with the immaterial which is abstracted from the senses. Physics deals with the patterns of the material things themselves.

For example, Newton's three laws of motion describe the causes of acceleration and what happens when two objects interact with one another. These are descriptions of material things and patterns in the

¹³ Ptolemy, *Almagest*, I, 1. Available online—see the section *References* for details.

¹⁴ Thomas Aquinas, *Super Boethium De Trinitate*, q. 5–6, trans. Armand Maurer. Available online—see the section *References* for details.

¹⁵ *Ibid.*, q. 5, a. 1.

material, concrete universe. In Aristotle's terms, Newton's laws tell us about what is mutable. Anything that is in motion, that undergoes any change, including change of location, is mutable. Newton's laws are established and tested through a concrete method. Today, we would say that these laws are established and tested through experiment, and experiments need concrete, i.e. mutable, objects. The mathematics that is used in physics is immaterial, but the mathematics is only the language of physics, not physics itself. Words and ideas are also necessary for physics, but physics is not a mere matter of words and ideas. Physics is mathematics, words, and ideas *about* the physical world.

As an example of metaphysics, Aquinas's idea about fundamental Being serves as an ideal model. Aquinas did not arrive at his conclusion through experiment. He conducted his analysis using the immaterial intellect and through argumentation. He uses what is immaterial to reason about what is immaterial and unchanging. There can be no experiment that will verify or disprove Aquinas's metaphysical foundation since experiments are restricted wholly to the material world.

Indeed, it must be noted that both metaphysics and physics begin through observation and are animated by wonder. There can be no doubt that both have a common origin. Humans begin with the senses, and all the sciences grow out of what is abstracted from them.

The question of whether or not there is beauty in physics certainly deals with physics, but it deals with physics "from the outside." If there is beauty in physics, that beauty is not one of the things that physics studies. Beauty is not one of the material and changeable things that must be studied in matter. In our terms, no experiment can be performed to determine whether or not beauty is in physics. The investigation needs a broader category: philosophy.

Now that it is clear in which scholarly house the question dwells, the nature of beauty has to be determined so that it can be more clearly identified if it is present in physics.

The Nature of Beauty

One of the issues concerning beauty that must be addressed is the fact that beauty, as a separate discipline, was not really established until fairly recently.¹⁶ One of the reasons this field of study had not developed earlier is that all ancient and medieval philosophers agreed on the reality and existence of beauty, and it is primarily from these philosophers that this paper will draw its understanding of beauty. Francis Kovach, in *The Philosophy of Beauty*, writes, "That which, when known, delights has always been called the beautiful."¹⁷ Only in modern times has the truth of beauty been brought into question, and philosophers have given this specific study the name of *aesthetics*. Kovach defines it this way: "Aesthetics is that generic area of human knowledge within which the beauty of certain things is either the object matter or (a part of) the subject matter of the various specific aesthetic sciences."¹⁸ If the question has to do with whether or not something is beautiful, then it is a question of aesthetics. Since the reality of beauty is in question, this domain is still within the confines of metaphysics, within the discipline that deals with questions regarding what is. The question about beauty in physics is located at the conjunction of metaphysics and the philosophy of science.

The first and most important thing to note about beauty in the context of society today is that beauty is real, not merely a matter of opinion or personal preference. Beauty is not only "in the eye of the beholder." The topic of discussion is one of truth, not taste. This is important because, if beauty is to have a nature, it has to be real.

¹⁶ Francis Kovach, *Philosophy of Beauty* (Norman, Okla.: University of Oklahoma Press, 1974), 5.

¹⁷ *Ibid.*, 56.

¹⁸ *Ibid.*, 24.

It is true that people often disagree about what is beautiful, but that can be attributed to the fact that, as Plato writes, “Beautiful things are difficult.”¹⁹ In other words, it is not easy to understand beauty. Kovach, commenting on Plato, elucidates the problem, “we learn from Plato the following paradox: beauty can easily, effortlessly be recognized in aesthetic experience, since this is a matter of intuition; and yet, it is very difficult to reason out its essence.”²⁰

Apparently, Aristotle dealt with relativists, including those who say that beauty is only a matter of taste, in his own time as well. “To attach equal importance to the opinions and impressions of opposing parties is foolish, because clearly one side or the other must be wrong.”²¹ He writes that when people disagree, it is most often the case that one of them is not perceiving correctly, sometimes from the result of an unhealthy organ. The truth of the matter can be settled by appealing to the healthy organ. It is not different when it comes to truth, goodness, and beauty. “And I hold the same in the case of good and bad, and of beautiful and ugly, and of all other such qualities,” writes Aristotle,²² another aesthetic realist who recognizes that beauty is not easy.

Given the fact that so many people today consider beauty to be a *subjective* matter of taste, it is part of the animating wonder of this paper that recognizes that physicists talk so forcefully about beauty and also are mostly in agreement about what is beautiful and the nature of that beauty.

This paper will follow the path trodden by Plato, Aristotle, Aquinas, and a few Thomistic philosophers like Francis Kovach through the dense forest of the philosophy of aesthetics in particular and metaphysics

¹⁹ Plato, *Hippias Major*, 304e, trans. W. R. M. Lamb. Available online—see the section *References* for details.

²⁰ Kovach, *Philosophy of Beauty*, 139.

²¹ Aristotle, *Metaphysics*, XI, 1062b.

²² *Ibid.*, XI, 1063a.

ics in general. Even though these three great thinkers did not leave any separate treatises on beauty itself, they wrote enough to help later thinkers find their way.

Plato also gives a way of identifying beauty that would stand the test of time: “That part of the pleasant which comes by sight and hearing is beautiful.”²³ What delights when seen is beautiful. This identification is helpful, but it is not a definition. Indeed, for the purposes of this paper, it gives very little to work with because physics is not “seen.” However, physicists and mathematicians certainly identify a kind of pleasure that comes with understanding great proofs and laws. Nevertheless, Plato identifies beauty as a “that which,” as something real.

Thankfully, Plato goes on to state even more clearly the reality of beauty in the *Symposium*. “Soon he will of himself perceive that the beauty of one form is akin to the beauty of another; and then if beauty of form in general is his pursuit, how foolish would he be not to recognize that the beauty in every form is and the same!”²⁴ According to Plato, there is a nature of beauty.

Further on in that same work, he identifies, through the words of Diotima, some of the nature of beauty. After describing the famous “ladder of love,” Diotima claims that one who has climbed that ladder will see the essence of beauty itself: “[B]eauty absolute, separate, simple, and everlasting, which without diminution and without increase, or any change, is imparted to the ever-growing and perishing beauties of all other things.”²⁵ The lack of change is a corollary of simplicity. What is without parts cannot change. So, the key characteristic of beauty, according to Plato, is simplicity, i.e. unity. This is interesting since this is

²³ Plato, *Hippias Major*, 299b.

²⁴ Plato, *Symposium*, trans. Benjamin Jowett. Available online—see the section *References* for details.

²⁵ *Ibid.*

a characteristic of a beautiful theory so often identified by the physicists.

The beauty that Plato describes is not some thing that anyone ever perceives. The beauty we find in a landscape, a poem, or a piece of music is an attribute of that thing, not a separate thing by itself. Whether or not beauty is a thing in itself will not be discussed in this paper. It is the nature of the attribute of beauty that is important here. What is it that makes something beautiful?

In turning attention to Aristotle, passages can be found that support the aesthetic realism of Plato and build on his description of beauty as simplicity. In the *Poetics*, Aristotle writes that, “A beautiful object, whether it be a living organism or any whole composed of parts, must not only have an orderly arrangement of parts, but also be of a certain magnitude.”²⁶ Plato’s *unity* is found in the fact that Aristotle identifies that the beautiful object is “any whole.” Aristotle builds on Plato by pointing out that the beautiful thing must have an orderly arrangement of parts. In other words, it must have a harmony or symmetry about it. Aristotle’s point about it being a certain magnitude means only that it must be perceivable for us to identify it as beautiful. What is too big or too small cannot be seen in its *whole*-ness. The “orderly arrangement” recalls to mind, also, what many physicists identified as beautiful in their descriptions of beautiful theories. A thorough comparison of the claims will be carried out after clearly identifying the nature of beauty, but it is worth pointing out the similarities.

An important realization with respect to the quote from Aristotle is that an object has a more orderly arrangement the more unified it is. A lack of harmony is also a lack of unity. The orderly arrangement of a thing “flows from” the unity of the thing. Aristotle is expounding on

²⁶ Aristotle, *Poetics*, I, vii, trans. S. H. Butcher. Available online—see the section *References* for details.

what it means for a thing to be a whole. Extraneous parts detract from any thing's simplicity.

As an example of what he means, Aristotle cites the works of Homer. *The Iliad* and *The Odyssey* have beauty because they “center round an action that in our sense of the word is one. . . . For a thing whose presence or absence makes no visible difference, is not an organic part of the whole.”²⁷ Everything in the plot is related. The harmony of those works are an expression of their organic one-ness, their constant revolution about a single action.

Aristotle appeals to unity as what makes something beautiful in a passage of his *Politics*. In the context, he is discussing the good that results when many wise men combine their judgments into one greater judgment and when many good men combine their good qualities so that the result is a judgment or quality that is better than any one of the individuals. “The beautiful are said to differ from those who are not beautiful . . . because in them the scattered elements are combined.”²⁸ The combination of those good elements into a single unity is what makes it beautiful. A whole that is comprised of harmonious parts is beautiful. The whole would not be complete if the parts were not good in themselves and orderly in their arrangement. Here, again, Aristotle points to simplicity as the key characteristic of the beautiful, and simplicity is founded on good combination.

Thomas Aquinas builds on the work of Aristotle and Plato and identifies three main characteristics of beauty in things that are composed of parts: integrity, proportion, and brightness. Integrity is another word for what has been so far described as unity or simplicity, and proportion is another word for harmony, balance, and symmetry. The har-

²⁷ *Ibid.*, I, viii.

²⁸ Aristotle, *Politics*, III, xi, trans. Benjamin Jowett. Available online—see the section *References* for details.

mony and the brilliance are related to the unity, so unity turns out to be the key feature in Aquinas as in Aristotle and Plato.

Beauty includes three conditions, “integrity” or “perfection,” since those things which are impaired are by the very fact ugly; due “proportion” or “harmony;” and lastly, “brightness” or “clarity,” whence things are called beautiful which have a bright color.²⁹

Francis Kovach calls the definition of Aquinas a *triadic definition*³⁰ because Aquinas identifies three aspects of beauty.

It is worthwhile to look at each of these attributes identified by Aquinas to see how they tie together. Aquinas gives a brief explanation of each. This passage occurs in an analysis of the Trinity and how beauty as an essential attribute has been appropriated in a fitting way to the Son.

Aquinas offers the word *perfection* as a possible substitute for *integrity* (*integritas*). Perfection means that a thing is whole or complete, that it has finished becoming and is completely itself. The Son is called *perfect* because He has the complete nature of the Father. There is nothing of the Father that is lacking in the Son. In commenting on this passage Christopher Scott Sevier explains that, in this case, integrity “is a comparative feature of objects . . . pertaining to a kind of fit between the particular instance and its paradigmatic ideal.”³¹ The Son is a simple whole because the Father is a simple whole. Therefore, in the view of Aquinas, it is clear from this passage that “[a] beautiful object . . . is a completed whole, lacking defect.”³²

The next word, *proportio*, has a special meaning in this context because the Son has no parts, and so the proportion cannot be a kind of

²⁹ Thomas Aquinas, *Summa Theologiae*, I, q. 39, a. 8, trans. Fathers of the English Dominican Province. Available online—see the section *References* for details.

³⁰ Kovach, *Philosophy of Beauty*, 162.

³¹ Christopher Scott Sevier, *Aquinas on Beauty* (New York, N.Y.: Lexington Books, 2015), 116.

³² *Ibid.*, 117.

harmony of parts. Aquinas explains that the proportion, in this case, refers specifically to the fact that the Son is the “express Image of the Father,” i.e., the perfect representation of the Father. He argues that even a perfect image of something ugly is still called beautiful because of the exactness of the copy. There is a balance between the thing itself and the representation. The Son as the express image of the Father is the most extreme case of this kind of balance.

Elsewhere, Aquinas also affirms the idea that *proportio* most commonly means a harmony among combined and different parts. In a passage about God’s government and the presence of evil in the world, he writes, “The highest beauty would be taken away from things, too, if the order of distinct and unequal things were removed.”³³ Proportion is not only exactness of copy to original, but also the common sense way of understanding it: a rightly ordered combination of various parts. In the *Summa*, he writes, “Beauty consists in due proportion; for the senses delight in things duly proportioned, as in what is after their own kind—because even sense is a sort of reason, just as is every cognitive faculty.”³⁴ Aquinas here appeals to the common definition of beauty: that which pleases; but he goes further and indicates *why* the thing is delightful: the senses delight in due proportion.

A powerful example in this case is a good harmony in music. The right combination of notes is a due proportion that brings great delight, often even to untutored ears. Aquinas gives the example of the human body and writes that its beauty consists in “due proportion of bodily members.”³⁵ A body without proper proportions can be regarded as less than a complete whole. The harmony among the parts is part of the unity of the body. If one part is bigger than it ought to be or, think-

³³ Thomas Aquinas, *Summa Contra Gentiles*, III, q. 71, a. 3, trans. Vernon J. Bourke. Available online—see the section *References* for details.

³⁴ *S.Th.*, I, q. 5, a. 4, ad 1.

³⁵ *S.C.G.*, III, q. 139; *S.Th.*, II-II, q. 145, a. 2.

ing about the body from the point of view of function, if one part of the body is defective, the body is not the kind of unity that it ought to be. Proportion can be called, up to a certain point, a characteristic of unity.

The third attribute mentioned by Aquinas is “brightness or clarity,” (*claritas*). Sevier explains that proportion, in itself, lacks the power of self-expression even though an object must have due proportion to be known.³⁶ Any object that is not proportioned according to its nature is less like what it ought to be. What proportion ought to be is dictated by nature, and a thing is known insofar as the nature can be ascertained. A thing that is less like what it ought to be is ugly. It lacks the wholeness it ought to have according to its nature, and thus it lacks the ability to be known that it ought to have. Something that better approximates its nature is more intelligible. The closer something is to the nature it approximates, the more true it is. Sevier explains that this idea was communicated from the neoplatonists and through Dionysius.³⁷ Something that is beautiful is self-expressive, and it is this self-expressiveness that is called *claritas*. Aquinas writes, “Light makes beauty seen (*lumen manifestans*).”³⁸ It is for this reason that beauty is sometimes called *the splendor of truth*. Beauty is the testimony of truth, a theme that comes through clearly in the statements made by physicists about beauty and the role it plays in finding true theories. The Church also teaches that “truth carries with it the joy and splendor of spiritual beauty. Truth is beautiful in itself.”³⁹

In the context of Aquinas’s statements about the Son, it is the Son who makes the Father known. Within the Trinity, Jesus is the Father’s knowing of Himself, the splendor of his own intellect. The Son is

³⁶ Sevier, *Aquinas on Beauty*, 114.

³⁷ *Ibid.*, 112.

³⁸ *S.Th.*, II–II, q. 180, a. 2, ad 3, quoted in Sevier, *Aquinas on Beauty*, 114.

³⁹ *Catechism of the Catholic Church*, 2500. Available online—see the section *References* for details.

the “light and splendor of the intellect.”⁴⁰ The Father, who is supremely simple is also supremely intelligible, and the Son is the brilliance of that intelligibility of the Father to Himself. He also is the fullest revelation of the Father to mankind.

Regarding Aquinas’s example of the beauty of the human body, he writes that part of the beauty is “a certain clarity of color.”⁴¹ It is through color that the eyes see, and the beauty of the body cannot be seen without the clarity of that color. A lack of color would make the body unintelligible.

Even when it comes to the nature of the human person and the beauty of virtue, Aquinas says that spiritual beauty is made known through its actions and through the praise and honor of others.⁴² He writes that a person’s honesty is what makes someone’s spiritual beauty known. It is important to note that the particular word translated as *honesty* in Latin is *honestum*, and it means more to Aquinas than our typical English meaning of merely telling the truth. For Aquinas, *honestum* means *virtue*, rightness of action according to the nature of man.⁴³ Spiritual beauty and a man’s conformity with the true nature of man is made manifest through his actions. Sevier outlines Terence Irwin’s argument that Aquinas’s use of *honestum* follows Aristotle’s use of *τό καλόν*, the Greek for beautiful.⁴⁴ *Honestum*, virtue, is beauty in man.

Thus *claritas* is the knowability of the thing, the self-expression of something. The more whole it is, the more proportioned it is. The more well-ordered it is according to its nature, the more of a whole it is. The more like it’s nature, the more knowable it is. Simplicity, proportion and brilliance are all related to each other, and it is simplicity that

⁴⁰ *S.Th.*, I, q. 39, a. 8.

⁴¹ *Ibid.*, II–II, q. 145, a. 2.

⁴² *Ibid.*, II–II, q. 145, a. 2, ad 2.

⁴³ *Ibid.*, II–II, q. 145, a. 1.

⁴⁴ Sevier, *Aquinas on Beauty*, 120.

stands as the foundation for the other two. That it is an organic whole is the most foundational metaphysical aspect of a thing. Proportion and clarity flow in being from one-ness. This study of aesthetics proves itself, indeed, to be a study of metaphysics, a study of the is-ness of things.

After a lengthy discussion of philosophical thinkers from every age and their various ideas about the nature of beauty, Kovach synthesizes a simple definition of beauty that derives mostly from the thought of Thomas Aquinas but also is based on the work of Plato and Aristotle. Aquinas holds that the most beautiful thing, in fact Beauty Itself, is nothing less than God. In the philosophy of Aquinas, God is supremely simple and has no parts.⁴⁵ So, in this line of thought, a harmonious composition of parts cannot be part of the essential definition of beauty, but as has been seen already in this paper, proportion exists in God in another way, and proportion is an expression of the unity of a thing. Kovach concludes, “Beauty in general is order, that is, integral unity, or integral unity with or without proportionate parts.”⁴⁶ The emphasis on order is followed by the clarification that order is really about integral unity. What is ordered, i.e. proportionate or harmonious, is beautiful, but that order is evidence of the metaphysical foundation of an integral unity.

Aristotle is one source for this definition: “Beauty depends on magnitude and order.”⁴⁷ What Aristotle meant by *magnitude* has already been discussed. The important word at this point is *order*. Of course, Aristotle is not ignoring the importance of unity, but an ordered whole is an integrated unity.

Kovach appeals, in particular, to Aquinas, who writes that beauty is order.⁴⁸ And it has already been seen what role order plays in unity in

⁴⁵ *S.Th.*, I, q. 3, a. 7.

⁴⁶ Kovach, *Philosophy of Beauty*, 215.

⁴⁷ Aristotle, *Poetics*, I, vii.

⁴⁸ Kovach, *Philosophy of Beauty*, 162.

the thought of Aquinas. Kovach remains true to the philosophical tradition begun with Plato and Aristotle and elaborated by Aquinas.

In conclusion, the nature of beauty is integrated unity, a well-ordered whole. Beauty is that which being seen pleases, and what pleases the human mind is a well-ordered whole. If there are some who do not find beauty in an truly harmonious unity, it may be that the minds of those individuals are not ordered enough to see the order in the world. For example, if someone can see no beauty in Euclid's proof that the prime numbers are infinite, it is likely that the mind of that individual is not mathematically ordered enough to recognize the beauty that is there. A guitar that is out of tune can never produce beautiful music, and an ear that is out of tune can never perceive true beauty in music. Education is the process of ordering oneself to meet the order outside. Beauty without cannot penetrate ugliness within. Order cannot be understood by disorder.

Beauty and Physics

So far the nature of physics and the nature of beauty have been identified. It is time to find out if there is beauty in physics. The astute reader will already surmise the conclusion since the nature of beauty so closely matches the statements by the physicists regarding what they find beautiful in physics. If the physicists were not on to something real, they could not have gotten so close to the truth about beauty. "Because most scientists are not also skilled in philosophy (nor should we expect them to be), it is notable that when the best of our modern physicists come to explain what they mean by beauty, their views are remarkably like those . . . in the perennial philosophical tradition."⁴⁹ In the quotes cited above, the physicists mention simplicity, harmony, and

⁴⁹ Thomas Dubay, *The Evidential Power of Beauty* (San Francisco, Calif.: Ignatius Press, 1999), 38.

clarity among the characteristics of a beautiful theory, and those are the exact same elements discovered in traditional philosophy and all related to integral unity.

A historical example may be illustrative. Ptolemy's geocentric universe was the best model for the solar system at his time. There was simply no evidence that the earth was moving, so it made perfect sense to place the earth at the center of the other heavenly bodies as they revolved around it. The problem was that, as time went on, that model could not accurately predict the motions of the planets. So, the planets were put on circles on top of circles, known as *epicycles*, to make up for the difference. Hundreds of years went by, and other adjustments had to be made and more epicycles had to be added. In the terms discussed in this paper, the model suffered more and more from disproportion and disunity as more "add-ons" were introduced. Even the sun-centered model of Copernicus did not solve this problem. It is important to point out that these epicycles were, in fact, seen as a problem. There was a real sense that theories and models should be simple. When Kepler introduced his model of elliptical orbits, most people embraced it because of its vast simplicity over the model of circles and epicycles.⁵⁰ In the world of physics, the term *epicycles* is now an insult to a theory that lacks simplicity and is, therefore, probably not true.

Kepler's theory was simple because it gave all the planets a single path on which to travel without epicycles. Mathematically, this theory was much more concise. The theory was well-balanced because all the ideas harmonized well with each other. The theory was also brilliant; it had *claritas* because it gave a model that could accurately account for all astronomical observations. It shed light on what was happening and eventually helped Newton to formulate the theory of Uni-

⁵⁰ Cf. Thomas Kuhn, *The Copernican Revolution* (Cambridge, Mass.: Harvard University Press, 1957).

versal Gravitation and, thus, *why* it was happening. Those are the three aspects of something beautiful, and those are the three characteristics so often identified by physicists.

A critical point to make is that there is beauty in the theory. The theory is a model about the motion of the planets; it is something that lives in the mind of man. It is not a physical thing. It is a theory about physical things and it is verified or contradicted by concrete observations, but it is the idea itself that is regarded as beautiful. Can an idea be beautiful?

It is worthwhile to revisit some of the statements made by physicists in light of what has been established about the nature of beauty. First of all, almost every quote mentions the role beauty plays in identifying truth. Feynman: “You can recognize truth by its beauty and simplicity.”⁵¹ Heisenberg: beauty “is the most important source of illumination and clarity.”⁵² Dirac: “It is more important to have beauty in one’s equations than to have them fit experiment.”⁵³ Penrose: “A beautiful idea has a much greater chance of being a correct idea than an ugly one.”⁵⁴ These physicists are highlighting the characteristic of clarity, the self-expressiveness of a good idea. Beauty is the splendor of truth. An idea is beautiful because it reveals something true about nature.

The simplicity of an idea is also mentioned multiple times by physicists. Feynman, again: “You can recognize truth by its beauty and simplicity.”⁵⁵ Schrödinger: Einstein had a strong feeling for “the simplicity and beauty of ideas.”⁵⁶ Gell-Mann: “When you have something simple that agrees with all the rest of physics and really seems to ex-

⁵¹ Feynman, *The Character of Physical Law*, 171.

⁵² Quoted in Augros and Stanciu, *The New Story of Science*, 39.

⁵³ Quoted in *ibid.*

⁵⁴ Penrose, *The Emperor’s New Mind*, 544.

⁵⁵ Feynman, *The Character of Physical Law*, 171.

⁵⁶ Quoted in Augros and Stanciu, *The New Story of Science*, 39.

plain what's going on, a few experimental data against it are no objection whatever."⁵⁷ The simplicity of an idea consists in the fact that there is greater explanatory power in fewer ideas. Just as a more powerful intellect understands more by means of fewer ideas, so a theory is more powerful and beautiful if it can explain more motion with fewer ideas.

As already discussed, the Ptolemaic model, after many years with all of its epicycles, is an example of an ugly theory; it possessed less and less explanatory power and the ideas were increasing in number. It lacked harmony, simplicity, and the clarity of truth. The study of beauty in physics also includes the study of ugliness in physics, because any subject genus includes contrary opposites. The example of the ugliness of the Ptolemaic theory helps in the understanding of a beautiful theory. The study of unity also includes the study of disunity.

Newton's theory of gravitation, on the other hand, is a simple idea expressed in a single equation of three variables that explained all of the motions of the heavenly bodies known to his time. Not only did universal gravitation explain all celestial motion at the time, including the cause for Kepler's elliptical orbits, but it also explained why bodies fall on earth. That is an immense amount of explanatory power in a very simple idea.

So, a beautiful theory in physics is an idea with integral unity and simplicity that explains a wide array of physical phenomena. That is what a beautiful theory is, but why is there a connection between beauty and truth in physics? Why is there beauty in physics in the first place? Is the beauty found in physics due to something about man who describes or something about nature that is described?

The quote from Brian Greene gives some insight into the source of the beauty in physics. He writes that physicists are convinced that "theories have an elegance and beauty of structure on par with the

⁵⁷ Quoted in *ibid.*, 41.

world we experience.”⁵⁸ The world is beautiful, and so ideas about the world should be beautiful. The world that is explained by physics has an integral unity to it. From the perspective of Thomistic metaphysics, there is an extremely elegant Unity undergirding all of existence. So, ideas about the motion of those existing things also have an elegant unity to them.

Greene is not alone in his assertion about the beauty of nature:

Newton . . . ascribes simplicity to nature, not to man: “Nature is pleased with simplicity, and affects not the pomp of superfluous causes.” And the testimony of twentieth-century physicists is clear in this matter. Feynman declares, “Nature has simplicity and therefore great beauty.” He does not ascribe the beauty to the onlooker. And Wheeler asserts, “Every law of physics . . . goes back to some symmetry of nature,” not back to a symmetry of our minds. And Max Born affirms, “The genuine physicist believes obstinately in the simplicity and unity of nature, despite any appearance to the contrary.” In a conversation with Einstein, Heisenberg once said:

“I believe, just like you, that the simplicity of natural laws has an objective character, that it is not just the result of thought economy. If nature leads us to mathematical forms of great simplicity and beauty . . . we cannot help thinking they are true, that they reveal a genuine feature of nature.”

Chandrasekhar adds, “All of us are sensitive to nature’s beauty. It is not unreasonable that some aspects of this beauty are shared by the natural sciences.” Again, the source of beauty is nature, not man. Why is beauty found in natural science? Because nature is filled with beauty. Physicist David Bohm declares, “Almost anything to be found in nature exhibits some kind of beauty both in immediate perception and in intellectual analysis.” Henri Poincare says, “The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it; and he takes pleasure in it because it is beautiful. If nature were not beautiful, it would not be worth knowing and life would not be worth living.” And Carl von Weizsacker adds an explanation, arguing that “the often-cited principle of economy

⁵⁸ Greene, *The Elegant Universe*, 167.

of thought explains, at the most, why we look for simple laws, but not why we find them.”⁵⁹

If there is beauty in physics, it is because there is beauty in nature. There is no doubt that physicists have given a prominent position to beauty in physics, but physics would not be “natural philosophy” if it did not rely on a theory’s ability to predict results of concrete experiments. Physics is about nature, and it is reasonable to conclude that the beauty of nature results in beauty in physics.

It should be pointed out that this paper has not demonstrated that nature is in fact beautiful. The metaphysics of Thomas Aquinas and the testimony of scientists have been brought to bear on the matter, but that is not a demonstration. This paper has only sought to demonstrate that there is beauty in physics. The beauty in physics suggests that there is beauty in nature, but to flesh out that argument would require a separate paper of its own.



Is There Beauty in Physics?

SUMMARY

Given how often physicists talk about beauty, the author tries to understand what they are talking about, what they mean, and whether or not there is any truth to what they are saying. The main questions he addresses are: When discussing the nature and beauty of physics, are we doing physics, science, psychology, or philosophy? And, does the meaning of the physicists’ acclamations actually line up with the true nature of beauty? The author concludes that there can be truth in the statement that there is beauty in physics, and the physicists themselves would be able to say most authoritatively which theories are beautiful and which are not.

KEYWORDS

Thomism, physics, science, beauty, reality, beautiful, truth, nature, theory, metaphysics.

⁵⁹ Augros and Stanciu, *The New Story of Science*, 44–46.

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