

HITTING THE MARK: PROJECTILE MOTION AND THE “SEGNO LIETO” IN DANTE’S *COMMEDIA*

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This essay explores Dante Alighieri’s notion of projectile motion in relation to the question of the *beata vita*. The notion of impetus, or projectile motion, stood at the confluence of Greek philosophical rationality (mediated by a substantial Arabic corpus) and Christian thought, and it provides a unique window through which we may observe Dante’s original poetic elaboration of the ontological dynamics of the *impeto primo*, or first impetus. The first canto of *Paradiso* contains an extended reflection on the ontology of movement and its implications for human fulfillment. This elaboration of an impetus theory by Dante marks an original, significant, and hitherto unacknowledged poetic contribution to the problem of detached motion and should prompt further inquiry into the complex theological and philosophical implications of this theory of nature.

In a brief moment of retrospection, reflecting upon his entry into Paradise, the poet proclaims the glory of God in terms of movement and order:

La gloria di Colui che tutto move,
per l’universo penetra, e risplende
in una parte più e meno altrove. (*Par.* 1.1–3)

[The glory of Him who moves all things penetrates through the universe and shines forth in one place more and less elsewhere.]¹

The circumlocution “Colui che tutto move” defines God in terms of movement. Aristotle’s unmoved mover—a lower-case “colui che tutto move”—coincides philosophically with Christianity’s God, the upper-case “Colui” of these verses. The totality of all movement—“tutto”—is directed by this unmoved mover who is extrinsic, yet encompassing: in a movement from without to within, his glory

¹ All English translations are taken from *The Divine Comedy of Dante Alighieri*, ed. trans. Robert M. Durling, 3 vols. (Oxford: Oxford University Press, 1996–2011).

penetrates and shines throughout the universe. The use of the word *universo* also captures this collective totality of movement. All is moved *versus*, from the Latin *vertere* [to turn], into one, *unus* or *uni-*; yet all is moved by degrees, “in una parte più e meno altrove.” The idea of movement by degrees is pertinent to our discussion of projectile motion because it implies the possibility of incomplete movement or deviation from an end. In the second canto, Dante reiterates this idea of degrees in relation to movement:

Questi organi del mondo, così vanno
 come tu vedi omai, di grado in grado,
 che di su prendono e di sotto fanno. (*Par.* 2.121–123)

[These organs of the world thus descend, as you can see, by degrees, for they take from above and fashion below.]

We will look at the implications that follow from incomplete movement or a deviation by degree further on, but for now I would like to point out that both these ideas of motion hinge on a series of dynamic physical images given by Beatrice in the middle of canto 1. Here the poet unites physics with metaphysics in such a way that all processes, natural and supernatural, are causally connected.

Following the poet’s invocation of Apollo, Beatrice, with a “pio sospiro,” expounds on the order of the cosmos. She explains that all natures are moved by a given instinct:

Ne l’ordine ch’io dico sono accline
 tutte nature, per diverse sorti,
 più al principio loro e men vicine;
 onde si muovono a diversi porti
 per lo gran mar de l’essere, e ciascuna
 con istinto a lei dato che la porti. (*Par.* 1.109–114)

[In the order of which I speak, all natures incline in their different lots, closer to their origin or more distant from it; thus they move toward different ports over the great sea of being, each with an instinct given it to carry it.]

The natures indicated by Beatrice could have a number of meanings, but for the purposes of this essay, let us suppose nature to have a precise philosophical meaning deriving from Greek thought. The Greek term that was translated into Latin as *natura* was *physis*, or *φύσις*. Aristotle explains the term in his *Metaphysics* as follows: “the genesis of growing things . . . the primary immanent element in a thing, from which growth proceeds The source from which the primary

movement in each natural object is present in it in virtue of its own essence.”² Taking this as the order (or *nomos*, νομός) referred to by Beatrice implies the following: within each “nature” inheres an element unique to its very essence, and this element provides the motive force for growth and fulfillment of that essence. Every instance of natural motion, that is, one in which the source of movement is found within the body, points to a dynamic of movement defined as a tendency toward something one does not yet possess. In the pilgrim’s case, he stands on the threshold of a noetic process that will move him from earthly knowledge to intimate knowledge of the divine.³ The end of movement is outside of himself, yet the source of movement originates within.

This intrinsic mover and its navigational metaphor are also found in Aristotle’s *De anima*, where soul and sailor are one: the soul is the mover of the body in the same way that the sailor is the mover of the ship.⁴ But the direction of this locomotion (or movement according to place) is determined by a natural inclination. In Dante’s verses, these natures are metaphorically immersed in a sea of being, with some more or less proximate to their intrinsic source of movement (“più al principio loro e men vicine”) and some tacking more or less closely in their natural inclination in direction. Although we find little mention of inclination in Aristotle’s *De anima*, and only a passing reference to it in book 4 of the *Physics*, it is an important detail, which we shall examine more in depth further on.

The nautical imagery presented in these two tercets recalls a portolan map, with a proliferation of lines crisscrossing the Mediterranean and connecting its diverse ports. It marks a profound and unprecedented poetic reflection on the philosophical problem of movement and its potential for fulfillment. Movement is exercised by natures, the directions traced in the waves as straight lines between two points, a *termine a quo*, from which one departs, to the *termine a quem*, the final port, one of fulfillment or perfection: movement’s ultimate end, its *telos*. Dante represents this philosophical process poetically through the metaphor of navigation in an ontological sea, “lo gran mare de l’essere” (*Par.* 1.113) [the great sea of being].

The intimate philosophical association between movement and its fulfillment is further underscored by the rhyme scheme. The homonymic “porti” indicates both a verb of movement (*portare* in the third-person singular subjunctive

² Aristotle, *Metaphysics*, 5.4.1014b16–20. All references to Aristotle are taken from *The Complete Works of Aristotle: The Revised Oxford Translation*, ed. Jonathan Barnes, 2 vols. (Princeton, NJ: Princeton University Press, 1985).

³ For an examination of the scholastic disputes that surrounded the noetics of the beatific vision, see Christian Trotman, *La Vision Béatifique. Des disputes scolastiques à sa définition par Benoît XII* (Rome: École française de Rome, 1995), particularly chapters 5 and 6.

⁴ Aristotle, *De anima* 1.3.406a3–12 and 2.1.413a3–12.

[*Par.* 1.114]), and a noun indicating a coastal haven (the plural noun of verse 112). The two “porti” emphasize the similarity and the distinction within this concept of motion and fulfillment of movement while carrying forward the rhyme received from “sorti” (*Par.* 1.110), translated by Robert M. Durling as “lots,” that which is given by fate or divine providence. Again, the rhyme scheme further reinforces the philosophical assonance. From the diverse destinies present in virtue of something’s essence (“diverse sorti”), through a verb of movement (“porti”), to a final place of rest (“porti”), Dante harnesses his *terza rima* to perform philosophical feats of teleology.

As further explanation of the source of movement within an ontological order, Beatrice then provides an additional clarification, extending natural motion to the elements:

*Questi ne porta il foco inver' la luna;
questi ne' cor mortali è permotore
questi la terra in sé stringe e aduna* (*Par.* 1.115–117; italics mine)

[This carries fire on up toward the moon, this is the driving force in mortal hearts, this compresses and unites earth.]

Here the poet begins to outline with even greater emphasis his interpretation of the source of movement. A natural object’s specific nature—the “istinto a lei dato”—disposes it to natural change, or movement. But what is this instinct, or driving force? The anaphora “questi” unites three instances of natural movement: two are elemental, fire and earth, and they bracket the natural movement, or driving force, of mortal creatures.

Returning to our definition of *physis* (φύσις), we can discern nature in its Aristotelian sense as an inner principle of change and being at rest.⁵ When an entity moves or is at rest according to its nature, therefore, referring to its nature will serve as a causal explanation of such an event. Natural change, therefore, occurs according to these inner principles, the same principles that make an element such as fire always tend in movement upward, toward the sphere of fire, and that make the earth through natural inclination tend downward, toward “l punto al qual si traggon d’ogne parte i pesi” (*Inf.* 34.110–111) [the point toward which the weights all move from every direction].

Yet in this tercet Dante does not confine his examination of the sources of natural movement to the elements. He also defines this inner principle for the “cor mortali.” This natural movement is an inner motive impulse—the “permotore”—that resides within the mortal hearts of those who possess intellect and love. This “permotore” moves them “naturally.” The term derives from the Latin verb *permovere*, and while it may indicate by extension an incitement or influence,

⁵ Aristotle, *Physics* 2.1, 192b20–23.

etymologically it brings us back once again to *motus*, or movement. Its prepositional prefix *per-* further anchors this movement within the science of motion: it is motion through space. And not just any motion, as the “permotore” gives rise to a motion borne by the heart, the same heart that will later bear and distill the sweetness of the pilgrim’s divine encounter.⁶

This parallel between a general theory of movement and its relationship to human physiology is not unprecedented. Thomas Aquinas composed a work on the heart entitled *De motu cordis* that commenced “Quia omne quod movetur, necesse est habere motore, dubitabile videtur quid moveat cor, et qualis sit eius motus” [Since everything that is moved must have a mover, the problem arises: What moves the heart and exactly what kind of movement does it have?]. Aquinas goes on to note that the heart’s motion does not appear to be natural, since its movement is composed of opposites—push and pull—and natural movement is toward one opposite, not both. He too uses the example of elemental motion to make his point: “motus autem naturalis ad unam partem est, ut ignis movetur tantum sursum, et terra deorsum” [but natural motion is toward one opposite such as the motion of fire, which is only up, and that of earth, which is down]. Yet in spite of this apparent unnaturalness, Aquinas concludes, the motion of the heart is a natural result of the soul, which is the form of the living body, principally of the heart. He is also compelled to add that natural things, by definition, have their principle of motion within them.

Up until this point we have examined this expansive notion of movement in relation to natural movement, that is, as the primary immanent element from which motion proceeds. The metaphor of navigation on an ontological sea provided the image of a sailor directing motion from within. The parallels drawn between the mortal heart and elemental motion also draw from this idea of *physis*, or natural movement, and Dante draws a direct analogy between the intrinsic source of movement of the elements and that of the seat of the human soul. Yet in the tercet that immediately follows, the poet introduces another metaphor, that of the bow:

né pur le creature che son fore
 d’intelligenza quest’arco saetta,
 ma quelle c’hanno intelletto e amore. (*Par.* 1.118–120)

⁶ It is important to note that while love may act as the natural motive force in humans, such is not necessarily the case for other types of “matter”: “. . . e ancor mi distilla / nel core il dolce che nacque da essa” (*Par.* 33.62–63) [but still there trickles into my heart the sweetness born of it]. For a reading of the *Commedia* as a narrative of physio-spiritual “training” of the pilgrim’s heart, see Heather Webb, *The Medieval Heart* (New Haven, CT: Yale University Press, 2010), 123–35.

[nor does this bow propel only the creatures deprived of intelligence, but also those that have intelligence and love.]

The dynamic of movement introduced by the bow is what Aquinas, and others, had called a “violent” movement, that is, a movement whose source is not intrinsic but extrinsic. Yet for Dante, the movement communicated by the bow to the arrow is the *impeto primo*. It is the source of the motive power that propels the soul toward the “segno lieto”:

e ora li come a sito decreto,
 cen porta la virtù di quella corda
 che ciò che scocca dirizza in segno lieto. (*Par.* 1.124–126)

[and now thither, as to a decreed goal, we are carried by the power of that bowstring which aims toward the happy target all that it looses.]

The tension toward transcendence created by this movement, when fully aligned with its source, is co-natural to it, and the ultimate good, or *telos*, specific to a being’s nature, the “segno lieto,” is obtained by way of natural inclination or co-naturality. For Dante, our own powers of will and desire are co-natured in this way, embodied in the seat of the soul, “ne’ cor mortali.” When in accordance with a spiritual destination that lies beyond our current mortal state, the motion toward transcendence is a natural one. Indeed, this question of motion, both natural and violent, sustains the unfolding of the whole of the first canto.

But if Dante here is illustrating how all natures, human and otherwise, tend in their movement toward a predetermined end as to a final cause, is he embracing a sort of fatalism that precludes man’s free will? The response, to which we shall now turn, lies in this unique elaboration of physical motion, which draws within the realm of natural movement the Aristotelian notion of violent, or projectile motion, while reasserting a Christian metaphysical significance of variations in both degree and force.

Aristotle contrasts the inner principles of change and rest with active powers or potentialities, external principles of change and being at rest, which are operative on internal principles.⁷ The concept of an inner motive impulse was also an explanation proposed for the problem of projectile or detached motion in Aristotle’s science of movement. This problem arises from a universally accepted principle concerning the physical theory of movement first elaborated by the philosopher in his *Physics*, in books 3 to 8, as part of a systematic exposition of all of the basic aspects of motion in general. Because the *Physics* was part of an Aristotelian corpus that was available in Dante’s lifetime through a proliferation

⁷ See Aristotle, *Metaphysics* 9.8, 1049b5–10 and 9.1, 1046a11–13.

of translations, commentaries, and attributed works,⁸ it is essential not only to consider the ideas on projectile motion set forth by Aristotle in his *Physics* but also to briefly examine subsequent interpretations by translators and commentators, including an influential group from Muslim Spain, and the members of the faculty at the University of Paris.

Specific discussions on projectile motion are found in books 4, 7, and 8 of the *Physics*. Our examination begins in book 7, where Aristotle discusses the efficient causes of various motions ordered ultimately to a first unmoved Mover, itself devoid of motion. He formulates the following principle: "Everything that is in motion must be moved by something. For if it is not the source of its motion in itself it is evident that it is moved by something other than itself, there must be something else that moves it."⁹ Today, as the heirs to such conceptual frameworks as Galileo's law of falling bodies or Newton's laws of universal gravitation and of motion or Einstein's theory of general relativity, we would find ourselves compelled to explain why motion changes or stops, not why it continues. Yet for Aristotle, every motion, or change, demands a cause: "omne quod movetur ab aliquo movetur," as the principle was known in its Latin translation to Dante. This concept was reinforced by a second principle in which, as we saw in Aquinas's *De motu cordis*, "that which is the first movement of a thing—in the sense that it supplies not that for the sake of which but the source of the motion—is always together with that which is moved by it (by 'together' I mean that there is nothing between them)."¹⁰ Any motion at all, for Aristotle, requires a mover that is ontologically distinct from, yet in continuous contact with, the thing it is moving.

So how does one explain action at a distance in this physical system? What sort of motion is that which propels a thrown stone? Or an arrow in flight? According to the Aristotelian tradition, *motus separata* was classified not as natural movement, that is, an inclination toward a natural place, but as violent movement. It is movement away from its natural place. What *causes* this motion? The question was much debated in the Middle Ages because the concept of a causal force of a projectile raised a wide range of other implications in relation to Aristotelian theories of motion and also because the internal inconsistencies in Aristotle's own works facilitated a wide range of interpretations. The implications of a concept of communicated or impressed force on the projectile, for example, surfaced in theories of causality, questions on divine knowledge of future contingents, and, later, in Franciscan debates on eucharistic presence.

⁸ See Fernand Van Steenberghen, *Aristotle in the West: The Origins of Latin Aristotelianism*, trans. Leonard Johnston (Louvain: Nauwelaerts, 1955); Richard Sorabji, ed., "Infinite Power Impressed," in *Aristotle Transformed: The Ancient Commentators and Their Influence* (London: Duckworth, 1990).

⁹ Aristotle, *Physics*, 241b34–36.

¹⁰ Aristotle, *Physics*, 243a31–34.

How did Aristotle reconcile the motion of a projectile with an ontologically distinct and physically separate mover? He acknowledged this problem in the following way: he assumed air was the immediate cause of projectile motion. His assumption was due in part to his own framing of the argument: if anything involved in a process is necessarily brought about because of some agency and the proximate mover is by necessity correlative to what it moves, then a projectile must be moved by the medium, that is, the surrounding air in a vibrato-like concatenation of causality, resulting in a redoubled transmission of movement. Both movement and the capacity to act as mover are imparted upon layer after layer of air. When this transmission ceases, the next layer of air only moves the projectile object itself, and it then falls to the ground.

This particular solution was found wanting by John Philoponus, a Christian philosopher of the sixth century C.E., also known as John the Grammarian.¹¹ In his hands, the cause of projectile motion shifted from the medium to the projectile itself. He rejected Aristotle's postulate of air as both the recipient and communicator of movement and held that air acts as the source of resistance. Philoponus then proposed that an incorporeal force that the mover impresses upon the projectile functions as the cause for movement. The *virtus impressa*, or impetus, is then spent by the resistance posed by the air, and the projectile motion ceases. With this explanation, Philoponus resolves several puzzles: he transfers the transmission of movement to the projectile rather than the medium and also provides an explanation of how movement continues in spite of the removal of the external cause.

Philoponus's arguments would have a significant impact on the physical doctrine of Arab intellectuals who, in the course of elaborating ninth- and tenth-century Arabic translations of Aristotle's *Physics*, were also confronted with ideas transmitted by the related Greek commentaries. This corpus found attentive readers in the likes of al-Farabi, Ibn Sina (Avicenna), Ibn Bājja (Avempace), and Ibn Rushd (Averroes), all of whom reinterpreted Aristotle's medium theory to put forward their own theories of impressed projectile force indebted to Philoponus.¹²

Dante performs an extraordinary transformation of the concept, however, which colors canto 1 of *Paradiso*. Here the use of the impressed projectile force extends beyond a causal theory for projectile motion and serves as a paradigm for understanding the extent to which the poet harnessed variations on Aristotelian physics for his metaphysical framework. It is the *impeto primo*, to use

¹¹ For an overview of John Philoponus and an extensive bibliography of his work, see Koenraad Verrycken, "John Philoponus," in *The Cambridge History of Philosophy in Late Antiquity*, ed. Lloyd P. Gerson (Cambridge: Cambridge University Press, 2010), 733–55.

¹² See Helen Lang, *Aristotle's Physics and Its Medieval Varieties* (Albany: SUNY Press, 1992); Paul Lettinck, *Aristotle's Physics and Its Reception in the Arabic World* (Leiden: Brill, 1994); Matteo Di Giovanni, *Averroè* (Rome: Carrocci Editore, 2017).

Dante's term, that supplies the motive power which propels the soul toward the "segno lieto." Invoking the motive power of a bowstring aligned with divine providence, Dante views human orientation to the "segno lieto" comparable to an arrow aimed by its archer to the target. The verb used is *dirizzare*, to direct. This image of an arrow being launched by a bow summons two necessary qualities of motion: the first, uniformity in direction, that is, without error in breadth; and the second, rate of motion, a force of movement that will allow the arrow's shaft to reach its mark. This particular kind of movement therefore contains within it the possibility of missing the mark, of deviating in either breadth or length.

In the first case, uniformity in direction, we can either summon the image of a divine archer imposing with his bow a unidirectional aim on the arrow in order to hit the "segno lieto" ("che ciò che scocca dirizza al segno lieto") or we can return to our portolan map and to those movements spurred by natures that are "più al principio lor e men vicine": as the helmsman pilots his vessel, so too the will directs the human vessel. It is not a *source* of movement but a means of directing movement without any degree of error to its ultimate end, what Dante terms the "sito decreto." Dante's lexicon here is quite telling. The "sito decreto" places us within a specific interpretation of Aristotelian discourse from his *Physics*, the discussion of the place, or end, of natural movement. The same natural movement that was united by Dante in the anaphora of the demonstrative pronoun *questi* in *Par.* 1.115–117. In the case of the natural end of human movement, the "sito decreto," or ultimate end of this movement, is beyond the created world in the encounter with the divine. Yet if the will represents a means of directing movement, of rectifying the path toward the "sito decreto," the Aristotelian idea of the dynamics of a natural place that propels movement toward itself receives a further refinement here. As the earth draws a stone back to its natural place, "la virtù di quella corda" propels man. But in what does this virtue consist?

If we return to Aquinas, this time to the *Summa Theologiae*, he explains how virtues come to completion insofar as they are perfected by the supernatural virtue of charity, which is said to be "finis aliarum virtutum quia omnes alias virtutes ordinat ad finem suum" (*ST* IIaIIae.23.8.ad 3) [the end of other virtues, because it directs all other virtues to its own end]. Charity, or love, also moves the Augustinian man, "pondus meum amor meus; eo feror, quocumque feror" (*Conf.* 13.9.10) [My weight is my love, I am borne wherever I am carried]. Human love finds its natural fulfillment (natural in its etymological sense of inborn endowment) in charity. To return to Aquinas: "Natura enim diligit Deum super omnia, prout est principium et finis naturalis boni, caritas autem secundum quod est obiectum beatitudinis, et secundum quod homo habet quandam societatem spiritualem cum Deo" (*ST* IaIIae.109.3. ad1) [nature loves God above all things inasmuch as He is the beginning and the end of natural good; whereas charity loves Him, as He is the object of beatitude, and inasmuch as man has spiritual fellowship with God]. If charity, or love, is the virtue that unites us to God, how might this union be imperiled? While rectitude of will regulates

desire, allowing an individual not to waver in breadth from the final aim, what of the impetus of that virtue?

Let us return to the idea of the force received by an arrow launched by a bow, “la virtù di quella corda.” As I mentioned before, the arrow may fail to hit its mark in not one but two ways. Any degree of error in breadth will cause it to miss its target, but there is another risk as well: the lack of sufficient impetus to reach the target itself. As Philoponus would have it, the ambient resistance would be such as to suppress the original impetus impressed upon the arrow by the bow. How does Dante interpret this risk? Is this too a problem of the rectitude of the will? Or perhaps this a problem of bodies, of the greater resistance encountered by corporeal matter in this physical realm and in terms of the pull of bodily pleasure.

Vero è che, come forma non s'accorda
 molte fiata a l'intenzione de l'arte,
 perch'a risponder la materia è sorda,
 così da questo corso si diparte
 talor la creatura, c'ha podere
 di piegar, così pinta, in altra parte
 e sì come veder si può cadere
 foco di nube, sì l'impeto primo
 l'atterra torto da falso piacere. (*Par.* 1.127–135)

[It is true that, just as form often does not accord with the intention of art, because the material is deaf to respond, so at times from this course the creature departs that has the power to swerve, so driven, in some other direction; and just as one can see fire fall downward from a cloud, so the creature's first impetus drives it to earth, if deflected by false pleasure.]

An impetus is impressed upon an individual soul by its creator in the same way that an arrow receives its impetus from the archer's bow.¹³ The arrow would continue in its movement as long as its force remained stronger than the resistance

¹³ See also in the same canto: “L'animo, ch'è creato ad amar presto, / ad ogni cosa è mobile che piace, / tosto che dal piacere in atto è desto. / Vostra apprensiva da esser verace / tragge intenzione, e dentro a voi la spiega, / sì che l'animo ad essa volger face; / e se rinvolto inver' di lei si piega, / quel piegar è amor, quell'è natura / che per piacer di novo in voi si lega. / Poi, come 'l foco movesi in altura / per la sua forma, ch'è nata a salire, / là dove più in sua matera dura, / così l'animo preso entra in disire, / ch'è moto spiritale, e mai non posa / fin che la cosa amata il fa gioire” (*Purg.* 18.19–33) [The mind, created quick to love, can move toward everything that is pleasing, as soon as it is wakened into act by pleasure. Your power of apprehension takes from some real thing an intention and unfolds it within you, so that it causes the mind to turn toward it; and if, having turned, the mind bends toward it, that bending is love, that is nature which by pleasure is first bound in you. Then, as fire moves upward because of its form, which is born to rise to

encountered. It would be precise in its aim were it not diminished or deflected by something inclining it in a different direction, “così da questo corso si diparte / talor la creatura, c’ha podere / di piegar [. . .]” (*Par.* 1.130–132) [so, from this course, the creature strays at times because he has the power, once impelled, to swerve elsewhere]. Due to a contrary force resisting it, the *falso piacere* of the body, the virtue, or impetus, is extinguished, and the projectile is abandoned to an earthly fall.

At the very center of the *Commedia*, in *Purgatorio* 17, we find a similar metaphor with love as the dynamic center of man’s moral life, providing the impetus necessary for the divine encounter. It is explained by Virgil on the terrace of sloth, a term that we should hesitate to understand according to its current usage as a physical disinclination to action. In the case of the *Commedia*, the meaning of sloth needs to be understood in a broader sense of motion, one that relates the inactivity of inner impulses or mental activities, or motives, to a deficiency of love. The vice’s corresponding virtue, the love of the good, is reinvigorated on this terrace where the souls are “di voglia di muoverci sì pieni, / che restar non potem” (*Purg.* 18.115–116) [so full of the desire to move that we cannot stop]. If free will provides “diritta via,” or the accuracy in degree, it is love that provides the sufficient impetus.¹⁴

The tension needed to communicate and maintain a purposeful trajectory to the “segno lieto” indicated in the first canto of *Paradiso* invokes two necessary qualities of motion: uniformity in direction and a force of movement that will allow the arrow’s shaft to reach its mark. That Dante saw the domain of the physical sciences deeply imbued with the spirit of Christian theology should

where it may last longer in its matter, so the captured mind enters into desire, which is a spiritual motion, and it never rests until the beloved thing causes it to rejoice].

¹⁴ A multitude of verses could illustrate this concept, particularly those drawn from the central cantos of each canticle, a meticulously structured formal flourish worth further examination. Let Virgil’s words to Dante in the terrace of sloth stand for the many: “Né creator né creatura mai / . . . fu senza amore, / o naturale o d’animo, e tu ’l sai. / Lo naturale è sempre senza errore, / ma l’altro puote errar per male obietto / o per troppo o per poco di vigore. / Mentre ch’elli è nell primo ben diretto / e ne’ secondi sé stesso misura, / esser non può cagion di mal diletto, / ma quando al mal si torce, o con più cura, / o con men che non dee corre nel bene, / contra ’l fattore adovra sua fattura. / Quinci comprender puoi ch’esser convene / amor sementa in voi d’ogne virtute / e d’ogne operatione che merta pene” (*Purg.* 17.91–105) [Neither Creator nor creature ever . . . has been without love, whether natural or of the mind, and this you know. Natural love is always unerring, but the other can err with an evil object or with too much or too little vigor. As long as it is directed to the first Good and moderates its love of lesser goods, it cannot be a cause of evil pleasure, but when it turns aside to evil, or when with more eagerness or less than is right it runs after some good, it employs his creature against the Creator. Hence you can comprehend that love must be the seed in you of every virtue and of every action that deserves punishment].

come as no surprise to readers of the *Commedia*. Yet these poetic instances of Dante's experimental physics of the soul mark a singular contribution to expanding our knowledge of how the science of natural bodies and the science of being *qua* being, or metaphysics, mutually informed and reinforced each other in Dante's work.

Many scholars of medieval physics and philosophy (such as Anneliese Maier, Hans Blumenberg, Marshall Clagett, and others)¹⁵ date the first detailed formulation of impressed force in impetus theory to the Franciscan and Scotist Franciscus de Marchia and his lectures on the *Sentences* given at Paris during the academic year of 1319–1320; and to the subsequent elaboration by Jean Buridan in his commentary on Aristotle's *Physics*, composed approximately a decade later. Dante's poetic elaboration of *impeto primo* and its role in propelling humanity to the *beata vita* through the mouth of Beatrice in *Paradiso* 1, however, should prompt some caution in attributing such paternities and force us to reconsider the philosophical possibilities afforded to Dante by the capacious quiver of poetic verse.

By appropriating the terms and the concepts of both Philoponus's idea of impressed force and the Aristotelian doctrine of natural place and by inscribing both within a poetic realm of *terza rima*, Dante places a physical phenomenon at the service of his metaphysics through the resources of verse. The metrical structure reflects this double dynamics of "from the origin" and "towards the origin"; in doing so, it reconciles the contrast between linear movement with that of circular movement while approximating notions of an extrinsic and intrinsic impetus. It is perhaps through these coordinates provided by the poet himself that we might continue to shed light on the "dottrina che s'asconde / sotto 'l velame de li versi strani" (*Inf.* 9.62–63) [the teaching that is hidden beneath the veil of these strange verses].

¹⁵ Anneliese Maier, *Die Vorläufer Galileis im 14. Jahrhundert: Studien zur Naturphilosophie der Spätscholastik* (Rome: Edizioni di Storia e Letteratura, 1949); Hans Blumenberg, *The Genesis of the Copernican World*, trans. Robert M. Wallace (Cambridge, MA: MIT Press, 1987); Marshall Clagett, *The Science of Mechanics in the Middle Ages* (Madison: University of Wisconsin Press, 1961).

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