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# Notes on Nāgārjuna and Zeno on Motion

by Brian Galloway

(1) In interpreting Nāgārjuna's *Mūlamādhyamikakārikā* 2.1b, *gatāgatavinirmuktaṃ gamyamānam na gamyate*, we find that the law of the excluded middle applies:<sup>1</sup> a thing must be either A or not-A, in this case either *gata* or *agata*. A thing proved to be neither can hardly exist and can at any rate have no relation to *gam*. Candrakīrti starts, to be sure, with a third possibility, that of *gamyamāna*; but he concludes,

*na ca gata-agata-vyatirekeṇa tṛtīyam aparam adhva-jātaṃ paśyāmo gamyamānam nāma; yataś ca evaṃ gamyamānam na gamyate, gamyata iti na prajñāyate tasmān nāsti gamyamānam. ato na tad gamikriyayā āviśyate; na gamyata iti: nāsti gamyamāne 'pi gamanam.*<sup>2</sup> [emphasis added]

Now as far as words are concerned, there may seem to be a contradiction between *nāsti gamyamānam* 'there is no [point just now] being gone over' and *nāsti gamyamāne 'pi gamanam* 'there is no going over even at [the point supposedly] being gone over', which implies that there is such a point. All we wish to do here is to show that for Candrakīrti there is a sense in which there is no *gamyamāna*, because by the law of the excluded middle motion must occur only in either the *gata* or the *agata* portion of the road. For as Buddhapālita states,

*hdi la gal te hgro ba śig yod par gyur na, de soñ ba la ḥam, ma soñ ba la yod par hgyur.*<sup>3</sup>

"Here if there is any going-over, it must occur either at the gone-over or at the not-gone-over."

(2) The *na gamyate* is interpreted as *na vidyate* or *nāsti* (but not in a heavy-handed annihilationist sense). But actually Nāgār-

juna is making a rather clever pun here,<sup>4</sup> intending both “is not logically possible” (*na prajñāyate*) and “is not gone over”. In the sense that the *gamyamāna* is not logically possible, Nāgārjuna has reference to the law of the excluded middle, according to which a thing must be either *gata* or *agata*. In the sense that the “gone over” is not (in spite of the words) being gone over, he has reference to the argument in (3) below. In this context we must keep in mind, as both T.R.V. Murti and later K. Bhattacharya make clear,<sup>5</sup> Nāgārjuna is not discussing in Stanza 2 the thing that goes by rather the *loci* over which it moves, not the goer but the path gone over by the goer, a point seemingly missed by Sprung,<sup>6</sup> who conflates *having been moved over* with *having moved*; he suggests, as an “alternate” translation of *gatam na gamyate*, “what has moved does not move,” but this is not the meaning, which is “what has been moved over is not being moved over.”

(3) Nāgārjuna’s fundamental argument in *MMK* 2.1, *pace* Bhattacharya, can be most conveniently and clearly explained mathematico-physically. (This is just what Candrakīrti attempts to do with his foot analogy, as we shall see later.) Consider a line segment bounded by points *a* and *b* containing a fixed point *c* not equal to *a* or *b*. A moving point *x* moves from left to right along the segment. When can we say that *c* is being gone over by *x*? When *x* is to the left of *c* (Fig. 1), i.e., has not yet reached *c*, the latter is not being gone over. When *x* is to the right of *c*, i.e., has passed through it (Fig. 2), *c* is not being gone over. Finally, when the two coincide, i.e.  $x = c$ , only an instant of time elapses, that is, a time of zero duration, and there can be no motion in space during a time of zero duration. Besides, at this moment the two points are identical, are one, and so there can be no traversing or going over. There is no room for motion in addition to there being no time for it. Thus we cannot find out anything about motion here, just at the precise point where it should occur (if anywhere). Candrakīrti, in the quotation above, says just this: *nāsti gamyamāne ’pi gamanam* (“there is no going even on the being-gone-over,” i.e., there is no going even at the point supposedly being gone over, no motion even at the point supposedly being just now moved over). This is just what Nāgārjuna intends, of course, since he is attempting to show the falsity of the conception of motion. In short, there is no

*gamyamāna* because (a) it is neither *gata* nor *agata* and, being neither of these, it cannot be anything else either; and (b) there is no *gamana* even at the point of supposed motion and thus there can be no *gamyamāna*. If it is objected that the point *c* is at one time *agata* and at another time *gata*, but that Nāgārjuna calls it *gatāgatavinirmukta*, the reply is that Nāgārjuna does not call *c* *gatāgatavinirmukta*; rather he calls the *gamyamāna* *gatāgatavinirmukta*. But in Figs. 1 and 2 the point *c* is not *gamyamāna*; and it is not really *gamyamāna* when  $x = c$  either. As for the road, it consists of a *gata* and an *agata* portion; nothing is left over except a point of zero length and hence nonexistent; a point is really only an abstraction and not found in real life. *Vyavahārikavat*, however, Nāgārjuna does not deny that the *road*<sup>7</sup> is being gone over; to deny this would be to fly in the face of the *saṃvrtisatya*, the conventional reality that in Buddhism is never denied. Nāgārjuna denies that the *point* at which motion supposedly occurs is being gone over; this is matter of *paramārthasatya*. Finally, if of the interval (*a*, *b*) the *gata* portion (*a*, *c*) in some sense represents the past and the *agata* portion (*c*, *b*) the future, then of the point  $x = c$  we can say with Bateau that it is *sans passé ni futur en fonction desquels il puisse se mouvoir*.<sup>8</sup>

It was after the foregoing was written that the present writer consulted the work of Siderits and O'Brien,<sup>9</sup> mentioned unfavorably by Bhattacharya, to see whether indeed they had "demonstrated nothing, because of philological limitations."<sup>10</sup> On examination, their argument on this point turns out to be perfectly sound; they even have a line diagram like the above, if somewhat less strictly mathematical. Bringing up the philological limitations of others is of course valid in general; but after all, we all have them; the present writer for instance knows no Greek and is thus forced to depend on what he devoutly hopes to be the competent translations of others; he does, however, have enough of the language of mathematics to have a sense of whether a mathematization of Candrakīrti's arguments is valid. In any case, what philological limitations are meant in the present case? The Sanskrit of Siderits and O'Brien turns out to be quite competent.

It is difficult, on the other hand, to agree with Siderits and O'Brien that Zeno's four paradoxes constitute a coherent system.

Three of them can be disproved fairly easily.<sup>11</sup> But in the arrow paradox Zeno is quite correct and his argument is precisely that Nāgārjuna and Candrakīrti. The arrow cannot move where it is not, and the length of space where it is has no further length where motion might be possible; and a given point on the arrow cannot move where it is not, nor where it is, because there is no room for motion in a point of space. Here is Aristotle's version of Zeno as quoted by Burnet:<sup>12</sup>

The arrow in flight is at rest. For if everything is at rest when it occupies a space equal to itself, and what is in flight at any moment always occupies a space equal to itself, it cannot move.

Here the inexactness of Zeno's method of expressing himself cannot conceal that he has struck at the very concept of motion itself. It is doubtless incorrect to call a moving object "at rest," but this follows from its being at a particular point at every particular moment; so the identity of motion and rest explodes the notion of motion.

*Pace* Burnet, it makes no difference that the arrow has length; we can just as well speak of a moving point, thought of as the arrow's tip or as any fixed point along the arrow's length; the point will occupy the point where it is on the flight path at any point in time. Now it will not do to assume first that "motion" is a viable concept and then attempt to calculate the rate of motion at a point as Vlastos<sup>13</sup> does. Zeno's argument is on a deeper level entirely. He shows that the whole idea of any motion is untenable and absurd. Aristotle's formulation is important here: "Neither moving nor resting are possible in the 'now' [i.e., instant]."<sup>14</sup>

So it is not true what Bhattacharya says, that the argument of Nāgārjuna "has nothing to do with Zeno's arrow paradox", as regards motion their arguments are precisely the same. The difference between them concerns *rest*, as Murti has pointed out with his customary insight and clarity:

That exists whose opposite exists, e.g. darkness and light, or this side and the other side. Logically therefore, a denial of motion involves that of rest as well. It is here precisely that Nāgārjuna proves himself a truer dialectician than Zeno.<sup>15</sup>

As for the foot analogy, neither Bhattacharya on the one hand nor Siderits and O'Brien on the other have got it right. The latter are not correct in stating that Candrakīrti's foot analogy, as given in the extant texts, has the walker going backward;<sup>16</sup> there has been no textual error. What Candrakīrti states is that the area covered by the foot cannot be regarded as "being gone over" because the foot itself consists of particles, and we must choose one of those particles to examine. Taking the atom at the tip of the toe, we find that everything behind it has been gone over as far as that atom is concerned and everything in front has not. In a separate examination, we find that from the standpoint of the atom at the heel, again everything in front of it has not been gone over from its point of view and everything behind it has. Then Candrakīrti meets another possible objection, that the atom itself has length, by pointing to its divisibility; if the atom is not in itself a point, we can look at an ever smaller portion of it. Logically, he is getting at the (lengthless) point by, essentially, a series of nested intervals. The divisibility of matter is by no means necessary to his argument. He only divides matter in order to arrive logically at the mathematical point, which can be seen as the limit of an infinite number of nested intervals that decrease sufficiently fast: consider the interval  $(0, 1)$ , then the ("nested") one  $(0, 0.5)$ , then  $(0, 0.25)$  and so on. "That atoms have spatial extension" (Bhattacharya) is not at all essential to Candrakīrti's argument. Candrakīrti is not talking about matter but about motion. His arguments are best seen in terms of a point, which means that atoms without spatial extension would have been even better for his argument. His foot analogy shows that we can arrive at a point *in spite of* the spatial extension (assumed by the Buddhist audience to whom his works are addressed) of the atom, because as long as it has spatial extension it will be infinitely divisible and thus we can arrive at a point as the limit of a series of nested intervals anyway. Nineteenth-century mathematicians would have criticised him for not making his argument explicitly in terms of a point; twentieth-century mathematicians would however be inclined to give him good marks for approaching a point as the limit of an infinite number of nested intervals and in general defining a point as the limit of a process.

By Buddhist standards, of course, there is no real ontological

status of the point being gone over, or to any mathematical point, because a point is only an abstraction, a figment of the imagination (*nāsti gamyamānam*). But we can imagine it. And if we do so, even then we find that motion over it is inexplicable (*nāsti gamyamāne 'pi gamanam*).

## NOTES

1. One knows that this is a matter of controversy in some circles; but see D.S. Ruegg, "The Uses . . .", *JIP* 5 (1977) 1-71.

2. *Bauddha Bharati* Series 16, ed. Dwarika Das Shastri (Varanasi: 1983) 35.

3. *Mūlamadhyamakavṛtti*, ed. M. Walleser (Bibliotheca Buddhica XVI), (St.-Petersbourg: 1913) 34. Breaks off in Chapter 13.

4. See J. Hopkins, tr., "Analysis of Going and Coming," (Dharamsala: 1974) 25.

5. T.R.V. Murti, *The Central Philosophy of Buddhism* (London: 1960) 178 ff; K. Bhattacharya's article in *JIAS* 8(1) (1985) 7-15.

6. M. Sprung, *Lucid Exposition of the Middle Way*, (Boulder, Colorado: 1979) 76 n. 6. He also translates Candrakīrti's *gataṃ tāvad gamyata iti na yujyate* ("the gone-over then is being gone over' does not make sense") as "it is not tenable to say what has been traversed is in motion" (pp. 76-77). But no-one maintains that what has been traversed is in motion. He gives an alternate translation in the footnote on p. 77; "past motion moves," but this is not what Candrakīrti's opponent says nor is it maintained by anyone. Sprung's belief that Nāgārjuna's "Sanskrit terms are both spatial and temporal, inextricably" (p. 76 n.) is not borne out by the precise way in which Nāgārjuna uses the language; in particular, the distinction between active and passive, which in colloquial Sanskrit is often brought to naught (and where indeed *gata* frequently means the active "gone") is strictly observed, I believe, by Nāgārjuna; at least it is difficult to make sense of his writing if one neglects it.

That we have to do this verse not primarily with a moving object or with movement as an abstraction but with the *loci* over which motion may occur—that for instance *gataḥ* does not mean something that has 'gone (moved) or something that has been 'gone to' (reached), but something that has been *gone over* (traversed)—has been missed by most translators. As quoted by M. Tachikawa ("A Study of Buddhapālita's *Mūlamadhyamakavṛtti*" (1) [*Journal of the Faculty of Literature of Nagoya University* 63, March 1974]), J. May gives us "le mouvement accompli ne comporte pas mouvement" and M. Walleser has "im Gegangenen eben ist nicht Gehen" (this from his 1911 work, and in his work of the following year we find "das Gegangene geht nicht"). Robinson as quoted by Tachikawa has "the gone is not arrived at", and Streng gives us "that-which-is-already-gone-to is not that which is 'being gone to'" (*Emptiness* [Nashville: 1967] 184). Tachikawa himself understands it properly e.g. "we

must not forget that Indian commentators allude or declare that '*gamyamāna*' indicates that which is being traversed" (p. 10). He quotes Avalokitavrata on this word: *sa phyogs gan na rkañ pa hdeg pa dan hjoj pañi mtshan ñid kyi gyo ba snañ ba de*. . . "the ground whereon there is movement in the form of lifting up and placing down one's feet". (The *gyo* will be *ga-hogya naro g.yo* 'motion'.)

7. Bhattacharya asks how Nāgārjuna can do this (*op. cit.* p. 9).

8. Bareau, quoted in Bhattacharya, *op. cit.*, p. 8; see also the German version, A. Bareau, W. Schubring, and Ch. v. Fürer-Haimendorf, *Die Religionen Indiens III* (Die Religionen der Menschheit 13), (Stuttgart: 1964) 156 ff. Bareau's interpretations of the MMK 2 are not, perhaps, the exact words of the ancient authorities, but they are certainly not bizarre; as regards time and motion he seems to have drawn on MMK 19 also. It is not clear to what Bhattacharya objects in Bareau's presentation.

9. M. Siderits and J. O'Brien, "Zeno and Nāgārjuna on Motion". *Philosophy East and West* 26(3) (July 1976), 281–299.

10. Bhattacharya, *op. cit.*, p. 8.

11. In the "racecourse", Zeno says that the mover from point *a* to point *b* must first go half the distance, then half the remaining (one-fourth of the total), then one-half of that (one eighth), and so on; and that because an infinite number of such distances must be traversed, and because each will take a finite amount of time to traverse, it will take an infinite amount of time to get to *b*, i.e., one will never get there. In fact, however, the time can easily be calculated. If a point moves at 1 meter per second from *p*<sub>0</sub> to *p*<sub>1</sub>, then it will require ½ second to go the first ½ meter, ¼ second to go the next ¼ meter, and so on; the total time will be

$$\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \dots = \sum_{n=1}^{\infty} \frac{1}{2^n} = 1$$

which even though it contains an infinite number of terms nevertheless sums to a finite sum (it is a convergent series—technically, a geometric series with ratio  $r = \frac{1}{2}$ , and when  $|r| < 1$  a geometric series converges to a finite sum). The Achilles and the tortoise paradox is not much more difficult to dispense with. By the formula  $s = vt$  (distance equals velocity times time) we can calculate as follows. Let Achilles's velocity be  $v_A$  and the tortoise's  $v_T$ , and let the head start enjoyed by the tortoise be  $h$ . The time taken by Achilles to reach the tortoise's original starting point  $h$  units ahead of him will be  $h/v_A$ . But in this time the tortoise will have moved  $v_T(h/v_A)$ , and Achilles must now traverse this distance, which he will do in a time  $v_T(h/v_A) / v_A$ . Continuing in this way we obtain Achilles's total time as

$$\frac{h}{v_A} + v_T \frac{h}{v_A^2} + v_T^2 \frac{h}{v_A^3} + v_T^3 \frac{h}{v_A^4} + \dots = h \sum_{n=1}^{\infty} \frac{v_T^{n-1}}{v_A^n}$$

This too is a geometric series, with ratio  $r = v_T/v_A$ , and if Achilles runs faster than the tortoise, this will be less than one, and the series will converge. Having convinced ourselves of this, we can then adopt the simpler method of setting

up two equations of motion of the form  $t = s/v$ , notion that we can put  $v_A = v_T + k$ , because the two speeds are constant and hence differ by a constant; and  $s_A = s_T - h$ . Thus

$$s_A = v_A t \text{ and } s_A + h = (v_A - k)t$$

are two equations in two unknowns and thus solvable for  $s_A$  and  $t$  by ordinary algebra.

As for the stadium paradox, this is based on not understanding that two bodies moving along the same line in opposite directions at the same speed move with velocities  $v$  and  $-v$ ; by subtraction one obtains their *relative* speed with respect to each other,  $2v$ , while their velocities with respect to a stationary observer are just  $v$  and  $-v$ .

12. J. Burnet, *Early Greek Philosophy* (London: 1930) 319.

13. G. Vlastos's attempt to disprove the arrow paradox (in Paul Edwards, ed., *Encyclopedia of Philosophy*, vol. 8, pp. 374–375) will not hold water; he attempts to find the velocity of the arrow at a point by dividing the distance traversed (zero) by the time taken to cover this distance (zero), obtains, naturally enough, the indeterminate form  $0/0$ , and concludes, apparently, that Zeno is wrong to state that the arrow cannot move at a point. But a mathematical absurdity ( $0/0$ ) cannot tell us anything about physical or philosophical reality; it can tell us that our mathematical tool has been badly chosen. Naturally we cannot use algebra to find the speed at a point of a moving body; this has been known since before Newton and Leibniz, whose invention of the differential and integral calculus had the purpose, in part, of providing a method for finding such a speed. In the case of a body moving with constant velocity  $v$ , we of course do not need the calculus; we can reason *a priori* that if it has the velocity  $v$  always, it must have the velocity  $v$  at any particular point. Of course one can insist on using the calculus anyway: for example, a body moving on the number line with a constant velocity of 20 between the points 5 and 15 will have the position function  $s = 20t + 5$ ; and the velocity function, by differentiation, using the power rule, will be  $ds/dt = 20$ ; in this (trivial) case the velocity  $ds/dt$  is constant (in the general case it will be a function of the position  $s$  or the time  $t$ ).

14. Quoted by Vlastos, *op. cit.*, p. 375.

15. Murti, *op. cit.*, p. 182.

16. Candrakīrti: *āṅguly-agra-avasthitasya paramāṅgor yaḥ pūrvō deśaḥ sa tasya gate 'ntargataḥ; pārśny-avasthitasya carama-paramāṅgor ya uttaro deśaḥ sa tasya agate 'ntargataḥ* (*loc. cit.*). Here *pūrvō deśaḥ* means the length previously traversed, thus *gataḥ*; *uttaro deśaḥ* is the length in front, to be traversed afterwards, later, thus *agata*. (The de la Vallée Poussin edition as quoted by Bhattacharya *op. cit.* does not differ in this passage.)

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## Errata to Vol. 10.2

Brian Galloway's "Notes on Nāgārjuna and Zeno on Motion" (*Journal of the International Association of Buddhist Studies* 10(2) (1987) 80–87) requires correction on the following points.

Figs. 1 and 2, first referred to on p. 81, were omitted and are now given here.

On p. 81 l. 10, for 'by' read 'but'.

On p. 83 l. 30, for the comma read a semicolon.

On p. 86, in the second displayed equation, the variables  $h$  and  $v$  should be understood as being of normal type size (not small as printed); the superscript numbers belong with the variables and not with the subscripts. Thus for example the second term should be understood as  $v_T h/v_A^2$  or  $v_T h/(v_A)^2$ . To the right of the summation sign read a fraction bar between the two terms. Thus we should have

$$\frac{h}{v_A} + \frac{v_T h}{v_A^2} + \frac{v_T^2 h}{v_A^3} + \frac{v_T^3 h}{v_A^4} + \dots = h \sum_{n=1}^{\infty} \frac{v_T^{n-1}}{v_A^n}$$

The fraction bars in the first equation should also have been horizontal.

On p. 87 l. 1, for 'notion' read 'noting'; second line from bottom, for 'de la Vallée Poussin' read 'de La Vallée Poussin'.

The title of the article, given correctly on p. 80, is incorrect on the contents page of JIABS 10(2); for 'in' read 'on'.



Fig. 1.

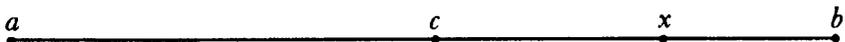


Fig. 2.