

IBN SĪNĀ—AL-BĪRŪNĪ CORRESPONDENCE (4)

Translated by Rafik Berjak and Muzaffar Iqbal

In this fourth installment of the correspondence between al-Bīrūnī and Ibn Sīnā, al-Bīrūnī asks eight more questions. His first question is related to the burning of bodies by radiation reflecting off a flask filled with water. The second question pertains to the well-known dispute about the natural tendency of the four elements in their upward and downward movements; the third relates to vision and the fourth deals with the habitation on different quarters of earth. In his fifth question, al-Bīrūnī asks Ibn Sīnā how the two opposite squares in a square divided into four can be tangential. The sixth question is about vacuum. In his seventh question, al-Bīrūnī asks: if things expand upon heating and contract upon cooling, why does a flask filled with water break when water freezes in it? His last question is related to one of the most important observable phenomenon: why does ice float on water?

Keywords: Ibn Sīnā–al-Bīrūnī correspondence; eight questions about physics; Islamic scientific tradition; nature of vacuum; properties of water and air; burning of objects by reflection of light.

Rafik Berjak is a scholar of Arabic language and literature; 9120152A Ave, Edmonton, AB T5E 5W1, Canada; Email: rberjak@shaw.ca. Muzaffar Iqbal is President, Center for Islam and Science, 349-52252 Range Road 215, Sherwood Park, AB T8E 1B7 Canada; Email: Muzaffar@cis-ca.org.

Islam & Science, Vol. 2 (Winter 2004) No. 2

© 2004 by the Center for Islam and Science. ISSN 1703-7603

[Eight more Questions on Physics and their Answers]

The First Question: If a spherical glass vessel is filled with clear water, it acts like a round burning glass. But when water is taken out and [the vessel] is filled with air, it does not burn and does not concentrate rays. Why does water act like that and not the air? And why does [water] have this ability to burn and concentrate rays?

The Answer: Water has a viscous body of light color and anything with such properties reflects light; this is why light reflects off a vessel full of water and successive reflections cause burning. As for the air, light does not reflect off it; rather, it reflects in it because air is in essence transparent. Therefore if the vessel has only air in it, the reflection will not be intense.

The Second Question: Who among the two is correct: the one who says that water and earth move toward the center and air and fire move away from the center or the one who says that all of them move toward the center but the heavier one arrives at the center before the lighter?

The Answer: The saying of the second person is false because if the fire moved toward the center, it would either arrive at the center or it would never arrive. If it never arrived then it is not moving toward it, rather, it is moving toward the place where it arrives. And if it [is said that it] arrived at the center, [then] that must be a lie because there is no fire ever seen coming down except by force such as falling fire balls. And what would such a person say about the fire that moves from the bottom [upward]; does it move naturally or by force? If he says that it moves by force, [then] it would become necessary that another body must move naturally toward it; and that is the one that first moved by force as we clarified. And if he says it moves upward naturally, then we have a body moving upward naturally and there is no body that moves upward naturally. This is self-contradictory because there is no body among the four bodies that moves upward naturally. Likewise, the heaven does not move upward in totality or in parts as we have already proven. There is, thus, no body that moves upward and if there is one that moves upward by force, another body will, by necessity, move to its place naturally and that would create inconsistency. Hence the latter is negated and that leaves the second as established, that is: fire moves upward naturally and that is what we wanted to clarify.

The Third Question: How is vision possible? Why can we see beneath water whereas the ray of vision reflects off opaque bodies and the surface of water is opaque?

The Answer: According to Aristotle, vision is not the result of the rays coming out of the eye; that is Plato's view. Although, upon examination, one finds that there is no [real] difference between the sayings of the two, for Plato said this for the commoners in their slang. This has been explained by Shaikh Abū Naṣr al-Farābī this in his book *al-Jam' bayna Ra'yain al-Ḥakīmīn* (*The Concordance Between the Opinions of the Two Wise Ones*). In Aristotle's opinion, vision results from the contact of the vitreous humor (*al-raṭūbatul jalīdiyyah*) of the eye with the transparent surface; [upon contact, vitreous humor] picks up the colors that are facing it at the parallel point of the body of which the color is the property. Since the vitreous humor is transparent, it would change and react to this color. And when this gelatinous substance changes, it becomes the instrument through which the faculty of vision perceives, this faculty recognizes the reaction that occurs and that is how vision becomes possible. There are more details about it in the commentaries on Book II of *Kitāb al-Nafs* (*On the Soul*) by the Philosopher and [in the commentaries] on his *Kitāb al-Ḥiss* (*Sense and Sensibilia*). So if that was that, and [since] water and air are transparent bodies presenting the nature of colors to the senses, doubt should disappear.

The Fourth Question: Why is only one quarter of the surface of the earth in the northern hemisphere settled and the rest is uninhabited while two quarters of the southern hemisphere are unsettled, [considering the fact] that laws pertaining to the two northern and two southern quarters are the same?

The Answer: The reasons that hinder habitation of regions are either the extreme heat or the extreme cold. [The reason for extreme heat] is the successive reflection by oceans of the sun's rays at right angle and the perpetual rise of the sun in these regions, as at the two poles. The reason for extreme cold is the reflection of the sun's rays at obtuse angles which are wide open and the perpetual sunset in these regions. And this is related to my field. As for the computation of the area of a place that cannot be inhabited, that is the job of the mathematicians and if it were not for your competency in that field, I would have discussed the little bit of geometry needed for such calculations, according to my abilities.

The Fifth Question: Suppose there are four surfaces (A, B, C, D) as in this figure and that there are imaginary lines between them which have no width. These planes are obviously tangential to each other through their sides. Now, whereas a plane has no dimensions but length and width, and if plane A is tangential to plane B along its length and to plane C along its width, then how is it tangential to plane D, as, obviously, things that are tangential to each other do not have anything between them. So, if planes A and D are tangential, how can planes C and B be tangential?

B	A
D	C

The Answer: Your saying—may Allah lengthen your life—that a plane does not have any dimension but length and width, is not sound. It is known that a plane has no dimensions except length; it does not have width; rather, it only has depth. It is apparent that if it had width then there would [also be] width to that width *ad infinitum*; and that is impossible. Therefore, it is impossible for plane A to be tangential to plane C along its width; if it is tangential at all, it has to be through the dimension of length as there is no other dimension to a plane than its length. As for your saying: “there can be nothing between the things that are tangential [to each other]”, it is incorrect, because between every two things that are tangential, [there exists] a common boundary (*faṣl*). And we are now going to clarify [the nature of] “tangent” (*al-tamāss*) and “connection” (*al-itiṣāl*) and [the difference between things] that can be said to be tangential and those which are not tangential.

Then we will return to the answer to the question, by the assistance of Allah, the Mighty and Majestic. We say that tangent, as the Philosopher has made it clear in Book V of *Kitāb al-Samāʾ al-Ṭabīʿi*, is the meeting of the extremities of things that are tangential and here it becomes imperative that there be a common boundary between the two tangential things; what is between is something other than the two tangential things. As for connection (*al-itiṣāl*), it is the union of the two joining things and here it becomes imperative that the common boundary between them be lifted. A body that has a side (*ṭarf*) and an extremity (*nihāyah*) can be tangential as well as a connected to another body, but whatever does not have a side cannot be tangential and connected at the same time; this is how [the Philosopher] negated things that are composed of indivisibles in [his] Book VI. A body can be tangential to another along its plane

that is its extremity, and a plane is tangential to another through a line which is its exclusive extremity, and a line is [said to be] tangential to another line through the point that is its exclusive extremity. And a point, because it does not have a side or an extremity—as it is [itself] the extremity of extremities—cannot be said to be tangential. And so is the case of existence of connection between three connecting quantities and vice versa, for as a whole, the point is indivisible.

And now we say that if any sort of meeting is imagined for the point, it should not be perceived in terms of tangent or union, but [in terms of] some other nameless kind. And you should know that this is also applies to planes and lines, for if the planes meet, [this union] will not be from the extremity which is the point; and it would not be called a connection or a tangent whatsoever; it cannot be defined in these terms at all. And you must know that if these bodies met in any of these manners and if they were planes, their meeting could not be considered to be through depth and if they were lines, they would not meet through planes and if they were points, they would not meet through lines and they keep their order. Thus, planes, when they meet, do not meet from the dimension of their extremities, and likewise, the lines and the point, when they meet, will not meet through another plane, line or point.

The proof for this is that if two planes met this way and they met on more than one side, they would be increased by one surface and that additional surface would undoubtedly be the depth; and depth is a result of the connection

B		A
	g	f
	j	e
I	h	C

between two sides and we did not add any other quantity between the two surfaces; we only had two surfaces, so from where did this quantity appear between them? And if there already was an existent quantity between these two planes, then they did not meet in the manner [of union (*iṣāl*) or attachment (*tamās*)]; rather, it merely appears to be the case, and [in reality] they did not have a union or attachment and there is separation between them unless we make this meeting sequential, but we did not make it like that. Thus, the two planes did not increase by one plane upon union—and more surfaces would follow the same order—because if the two planes from them met and did not increase by one upon meeting, the rule of each part of the resultant four from the two pairs would be the same rule as that of the pair and likewise would be the case for the

line and the point. Hence, we now say that plane A is tangential to plane B along its length only, or is connected to it, and plane C is likewise tangential or connected to it along its other length. So the three points (e, f and g) had met some kind of meeting, it necessitated their union so that the three points became one and from this emerged angle “h” and it is one point between both of them. If we added to the three united or connected planes, another plane (I), tangential or connected with its two lines to the line [connecting] planes C and B, its point “j” will be, metaphorically speaking, the common point between the three surfaces. So, if we assume them to be connected to each other, plane A will not exist in actuality; hence there will be no tangential [relation] assumed in this case; rather, the united planes will meet from the direction of the point which is the extremity of the extremities of the three lines which became one extremity. And if the extremities were not united and plane A in actuality and its point remained unconnected with the two points of planes C and B, then what would prevent plane I and its point, which is “j”, to be tangential? And likewise is the case of planes C and B.

The Sixth Question: If it is established for us that there is no vacuum inside or outside this world, why is it that if the air within a flask is sucked out and the flask is inverted on water, water rises up in it to the end of its limit?

The Answer: It is not because of vacuum, but the reason for this is that suction did not create vacuum and sucking moved air inside the flask through forced motion and successive movements created heat; the heat expanded air and when air is expanded in the flask, it requires more space, hence it is necessary that some of it must go out and whatever can find space will stay in the flask and upon contact with cold water, this air will compress and contract, requiring less space and because vacuum is not possible, water rises up in the flask to the extent of contraction of the air. Don’t you see that if you did not suck, but you did the opposite action of sucking—that is blowing—[your] successive blowings will heat up the air in the flask and if now you turned it upside down on the water, water will do exactly the same action [of rising] and this has been tested. And if you heat the flask, it would do this very same thing and this is enough for an answer.

The Seventh Question: If things expand upon heating and contract upon cooling, then why does a flask full of water break when water within it freezes?

The Answer: Indeed, it is possible to bring out the answer from the question itself. And that is [to say], as the body expanded upon heating, it required more space, so it broke the flask. Likewise, when the body contracted upon cooling, it took less space and that would have created vacuum in the flask, so it split and collapsed because of the impossibility of [the creation of vacuum]. And for this phenomenon, there are other aspects in physics and that is the reason for many of these happenings, but in what we have already mentioned, there is enough of an answer.

The Eight Question: Why does ice float on the surface of water although it is closer to earthy nature in its accumulation of cold and its rockiness?

The Answer: This is so because upon freezing, water preserves airy particles which prevent it from sinking.

And this is the answer to all of your questions. In case you have any confusion about these issues, I kindly ask you to refer them back to me so that I can explain and quickly send [the responses] back to you. And what can now cause a delay in these [responses] reaching you this time, as Faqīh al-Maʿṣūmi has already told me that he has finished copying them, by the grace and help of Allah. The answer to all the questions has now been completed. Thanks and praises are due to Allah, the Granter of intelligence at the beginning and at the end.

(To be continued)