# CONSTRUCTIVISM AT THE BIRTH OF THE SCIENTIFIC REVOLUTION: A STUDY OF THE FOUNDATIONS OF QUSHJĪ'S FIFTEENTH CENTURY ASTRONOMY

BY

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# ABSTRACT

This study explores the conceptual foundations and the intellectual structure in the works of ʿAlāʾ al-Dīn ʿAlī Qushjī (d. 1474) that led to an astronomical model, which research suggests has given a philosophical impulse to the Scientific Revolution in Europe. According to recent historiography of science, it was a specific astronomical model that contained a critical breakthrough for the mathematical foundation of Earth's motion. Until 2005, it was thought that Regiomontanus' (d. 1476) *Epitome of Almagest* (1496) had supplied this intellectual impetus to Copernicus' revolution in astronomy. But in 2005, it was discovered that Qushjī, Ottoman Sultan Mehmed II's chief scientist and *kalām* scholar, had authored an earlier Arabic version of this model. This study unravels the new program of science according to the emerging constructivist project of later Ashʿarite *kalām,* which was completed by Qushjī and turned into a comprehensive theory of knowledge to serve as a new foundation for astronomy and mathematics. It shows how in the fifteenth century, constructivist epistemology came to replace Aristotelian realism as a foundation for a new constructive astronomy. Qushjī's elucidation on constructive semantics in his works on *ʿilm al-waḍʿ* (science of denotation), as well as his philosophical discussions on mental existence (*al-wujūd al-dhihnī*) in his *kalām* work, *Sharḥ Tajrīd al-Kalām* (Commentary on Abstracting *Kalām*), facilitate this undertaking. The constructive revolution brought forward by Islamic astronomy emerges as the original mathematical revolution against geocentricism. It also provides us with the foundation for a contemporary critique of Copernican heliocentricism, which is currently known to be scientifically untenable. This opens the way for a better understanding of constructivism as a foundation for solving the contemporary challenge of quantum physics. As a result, constructivism, as a foundation for science, had existed in Ottoman Constantinople since at least the fifteenth century. Given that Kant's Copernican revolution of the late eighteenth century was itself a quest for constructivism, its delay until after the Copernican revolution implies that Kant was only attempting to historically unearth the imbedded constructive foundations of the earlier revolution in astronomy. This study helps us answer new critical questions about the historical development of constructivist epistemology, its rise and continuity in time and its early conceptual transmission across civilisational boundaries between Islam and modern Europe.

# ملخّص البحث

**منهجية المعرفة الإنشائية عند بروز الثورة العلمية: دراسة أصول علم الفلك لدى القوشجي في القرن الخامس عشر.** تتحرّى هذه الدراسة الأصول الفكرية والمنهجية المفاهيمية في أعمال علاء الدين علي القوشجي (م. 1474) والتي أدّت إلى نموذج رياضي فلكي تشير الأبحاث الجديدة الى أنه أعطى دفعة انطلاقية للثورة العلمية في أوروبا. بناءً على علم تاريخ العلوم، كان هناك نموذج فلكي احتوى على تقدم مفاجئ في المعرفة للأصول الرياضية لحركة الأرض. حتى سنة 2005، كان يُظنّ أن *ملخص الماجست* (1496) لريجيومونتانوس (م. 1476) هو الذي وفّر الدفع الفكري لثورة كوبورنيكوس الفلكية. ولكن في سنة 2005 تم اكتشاف أنّ القوشجي، العالم الأوّل لدى السلطان العثماني محمد الثاني (الفاتح) والمتكلّم، كان قبل ذلك قد دوّن رسالة رياضية في العربية حول هذا النموذج. يمكننا من خلال هذه الدراسة الكشف عن البرنامج العلمي الجديد المرتبط بتقدم 'مبحث الانشاء الذهني' (أو الوجود الذهني) لدى المدرسة الكلامية الأشعرية المتأخرة والتي أتممها القوشجي وحوّلها الى منهجية معرفية كاملة كأصول جديدة لعلم الفلك والرياضيات التطبيقية. نرى من خلال ذلك كيف أنّ مبحث الانشاء الذهني تبلور في القرن الخامس عشر حتى استبدل نظرية الواقعية الأرسطية (أو نظرية الشبح) كأساس يُبنى عليه بعلم الفلك الإنشائي الجديد. هناك عنصران أساسيان يساهمان في إتخاذنا هذه المهمة البحثية وهما؛ شرح القوشجي حول الإعتبار الذهني في رسائله في علم الوضع، و توضيحاته الكلامية في 'مبحث الوجود الذهني' في كتابه الشهير في علم الكلام، *شرح تجريد الكلام*. وهكذا فإنّ الثورة الإنشائية التي قدمتها الأصول الكلامية لعلم الفلك الإسلامي تبرز كالثورة الأساسية ضد النظرية الأرضية التي تقول بعدم حركة الأرض في نفسها. كما أنها تعطينا الأصول العلمية لتقديم نقض معاصر لنظرية الكون الشمسية لدى كوبورنيكوس والتي يُقرّ اليوم على أنها ساقطة علمياً. هذا أيضاً يفتح المجال لفهم بشكل أفضل كيف تشكل المنهجية الإنشائية في المعرفة أساس لحل معضلة الكوانتم الفيزيائية. في النتيجة، الفكر الإنشائي الذهني كان موجوداً في القسطنطينية تحت العثمانيين منذ على الأقل القرن الخامس عشر. وبما أن ثورة كانط الفلسفية في القرن الثامن عشر، والتي تسمى بالثورة الكوبورنيكية، هي استطلاع فلسفي لتحديد معالم الإنشائية الفكرية، هذا يؤدي بنا الى الاستنتاج بأنّ تأخّر تلك الفلسفة عن ثورة كوبورنيكوس سببه أنّ كانط كان يحاول أن يكشف عن الأصول الإنشائية المحتوية في الثورة الفلكية نفسها. تساعدنا هذه الدراسة على الإجابة عن أسئلة هامة وجديدة حول التطور التاريخي لمنهجية المعرفة الإنشائية، بالإضافة الى نشأتها واستمرارها الزمانيين وانتقالها الفكري المبكر عبر الحدود الحضارية بين الإسلام وأوروبا العصرية.

# APPROVAL PAGE

The thesis of Mustapha Kara-Ali has been approved by the following:

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El-Fatih Abdelsalam
Chairman

# DECLARATION

I hereby declare that this thesis is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Mustapha Kara-Ali

Signature……..……. Date January 3, 2014

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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Affirmed by Mustapha Kara-Ali

……..……..……  January 3, 2014

Signature  Date

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# TRANSLITERATION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ء | ’ | خ | kh | ش | Sh | غ | Gh | ن | N |
| ب | B | د | D | ص | ṣ | ف | F | ه | H |
| ت | T | ذ | dh | ض | ḍ | ق | Q | و | W |
| ث | Th | ر | r | ط | ṭ | ك | K | ي | Y |
| ج | J | ز | z | ظ | ẓ | ل | L | | |
| ح | ḥ | س | s | ع | ᶜ | م | M | | |

| Short Vowels | |
|---|---|
| ـَ | a |
| ـِ | i |
| ـُ | u |

| Long Vowels | |
|---|---|
| ا + ـَ | ā |
| يْ + ـِ | ī |
| وْ + ـُ | ū |

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# CHAPTER ONE

# QUSHJĪ AND THE COPERNICAN REVOLUTION

## 1.1 INTRODUCTION: PROBLEM AND SIGNIFICANCE

According to accumulating evidence in recent historiography of science, it was a specific astronomical model, known as *The Eccentric Model for the Second Anomaly of the Lower Planets*, that contained a critical breakthrough for the mathematical foundations of Earth's motion. In 1973, for example, and elaborating on the significance of this model as it appeared in Regiomontanus' *Epitome of Almagest* (Venice, 1496), Swerdlow remarked:

> Copernicus's derivation of this theory rests upon the eccentric model of the second anomaly and therefore upon [the] two propositions in the Epitome [by Regiomontanus]. In this way Regiomontanus provided the foundations of Copernicus's great discovery. It is even possible that, had Regiomontanus not written his detailed description of the eccentric model, Copernicus would never have developed the heliocentric theory.[1]

Swerdlow goes on to claim that "while I do not believe that Regiomontanus ever advocated the heliocentric theory, he was through these two propositions virtually handing it to any taker"[2]. The striking news, however, came in 2005 when Ragep published an Arabic treatise for *the eccentric model of the second anomaly of the lower planets*[3] that belonged to the fifteenth century astronomer and foundational scholar, ʿAlā'uddīn ʿAlī Ibn Muḥammad al-Qushjī, who had died in Constantinople in 1474.

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[1] Noel Swerdlow, "The Derivation and First Draft of Copernicus's Planetary Theory: A Translation of Translation of the Commentariolus with Commentary", *Proceedings of the American Philosophical Society*, vol. 117 (1973): 472.
[2] Ibid., 475-6.
[3] ʿAlī Qushjī's treatise named *Risālah fī anna aṣl al-khārij yumkin fī al-suflayayn* translated as *A Treatise on the Eccentric Hypothesis Being Possible for the Two Lower Planets* was published in the original Arabic with translations in F. Jamil Ragep, "ʿAlī Qushjī and Regiomontanus: Eccentric Transformations and Copernican Revolutions", *Journal of the History of Astronomy*, vol. 36, no. 4 (2005), 359-371.

Ragep went further by raising in this article the question of transmission, based on pictorial resemblance between the diagram published in his *ʿAlī Qushjī and Regiomontanus*, i.e. the one from an early fifteenth century Suleymaniye Library Manuscript by Qushjī and another from the late fifteenth century text, *Epitome of the Almagest* (Venice, 1496), by Regiomontanus, that Swerdlow had referenced in his 1973 article in relation to Copernicus (Figure 1.1).

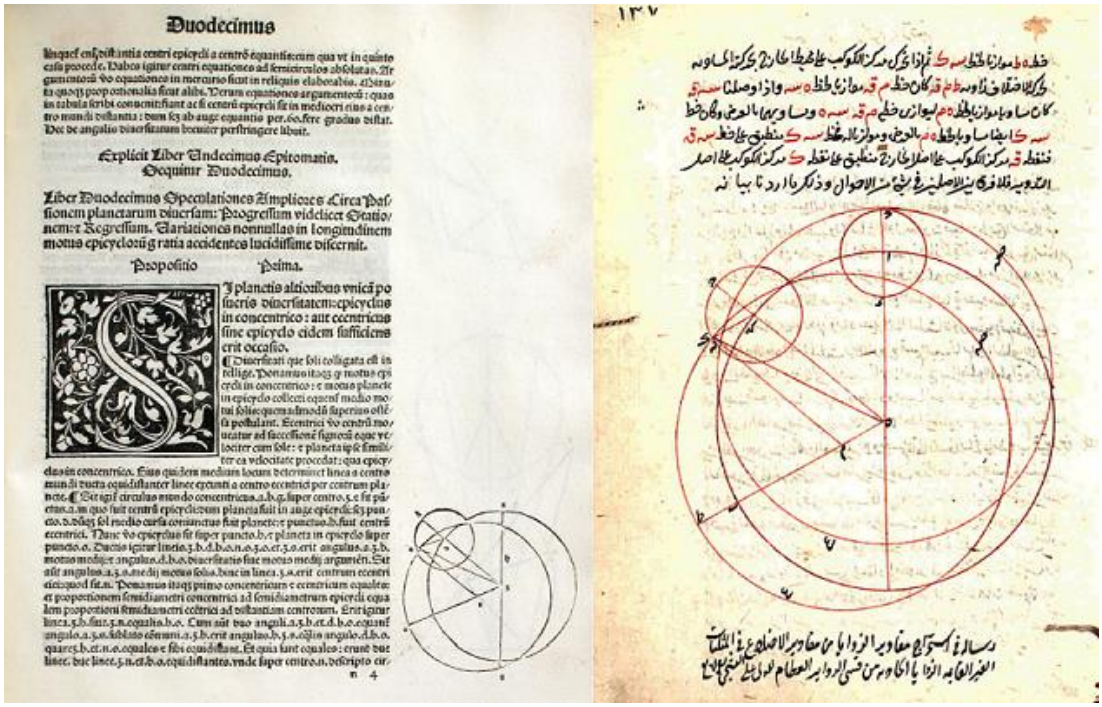


Figure 1.1 The figure shows two diagrams with close configurations: One from an early fifteenth century Suleymaniye Library Manuscript by Qushjī (right), and the other from the late fifteenth century text *Epitome of the Almagest* (Venice, 1496) by Regiomontanus (left).[4]

Despite such resemblance, however, our conceptual study, which traces the development of ideas and their historical rise and continuity in time and across

[4] The image is taken from a lecture poster titled *Islam at the Crossroads: Reflections on the History and Historiography of Astronomical Transmission* for F. Jamil Ragep's keynote talk at the University of Notre Dame's Eleventh Biennial History of Astronomy Workshop (June, 2013). The author of this dissertation, Mustapha Kara-Ali, presented a paper at this conference which was titled "Constructivism across Islam-European Boundaries in the Fifteenth Century". For more details about the workshop including access to this paper abstract refer to <http://www3.nd.edu/~histast/workshops/2013ndxi/index.shtml>, (Accessed 1 January, 2014).

civilisational boundaries does not rely upon the existence or the absence of a figure resemblance. The conceptual scheme and the intellectual structure of astronomical modeling is more important to the imbedded intellectual meaning and the impetus an astronomical model might give to a scientific revolution. Ragep, however, does make the following preliminary observation, which clears the way perhaps for one of the greatest studies yet to be conducted on the conceptual history and the birth of the Scientific Revolution. He adds:

> Since research has just begun into the legacy of ʿAlī Qushjī, in particular into the Istanbul circle of scientists that he helped initiate, we can only speculate [about their exact position]. But it is certainly of considerable interest that Qushjī like Copernicus was open to the possibility of the earth's rotation based on a new, non-Aristotelian physics.[5]

The interest here, therefore, does not lie solely in pictorial orientation, but should rather transcend such a reading to a conceptual and a philosophical inter-civilisational analysis. Ragep continues:

> Clearly there is more to the Copernican Revolution than some clever astronomical models that arose in the context of a criticism of Ptolemy. There also needed to be a new conceptualization of astronomy that could allow for an astronomically-based physics. But there is hardly anything like this in the European tradition before Copernicus. The fact that we can find a long, vigorous discussion in Islam of this issue (Earth's movement) should indicate that such a conceptual foundation was there for the borrowing.[6]

Moreover, accumulating evidence concerning likely conceptual transmission between Islamic astronomy and the Scientific Revolution in Europe, notwithstanding our later constructivist criticism of heliocentricism, have led Owen Gingerich[7] to recently make the following submission:

> A specific geometrical insight from the Islamic world might have given an indispensable impetus toward the radical heliocentric rearrangement.

[5] F. Jamil Ragep, "Copernicus and His Islamic Predecessors: Some Historical Remarks", *Filozofski vestnik*, vol. 25, no. 2 (2004):139 republished in *History of Science*, vol. 45 (2007): 65-81.
[6] Ibid.
[7] Emeritus Professor of Astronomy and History of Science at Harvard University.

> Around 1430, ʿAlī Qushjī, an Islamic astronomer, wrote a small treatise with a parallelogram transformation diagram that reappeared almost identically in Regiomontanus' *Epitome of the Almagest*, a volume finally published in 1496. That book, known to have been used by Copernicus, is most likely the source for an essential step toward heliocentricism. Perhaps a connection between Islamic astronomy and the making of the European scientific Renaissance really does exist.[8]

Despite such commentary, in the last few decades, the growing number of historians of science who have commented on Qushjī's works have done so by focusing mostly on his astronomical and mathematical works. To date, however, no comprehensive study has been conducted on Qushjī's foundations of science and his conceptual scheme that relates to what we later describe as being his revolutionary work with constructive astronomy. Indeed, the aforementioned 1973 study by Swerdlow, which was conducted over 30 years before Qushjī's model was rediscovered and published, points to the great need for a thoroughgoing study of Qushjī's astronomical work from a conceptual perspective; a task that is still to be taken up and which our investigation in this dissertation devotedly undertakes.

It is believed that the current study can contribute towards filling a crucial gap in contemporary historiography of science by studying how the foundations of astronomy from mid to late fifteenth century Islamic world might have influenced Latin Europe via the intellectual crossroad and the scholarly hub of Ottoman Constantinople[9].

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[8] Owen Gingerich, Review of "Islamic Science and the Making of the European Renaissance", *Journal of Interdisciplinary History*, vol. 39, no. 2 (Autumn 2008): 310-11.

[9] On this period and during the periods of the two Sultans Mehmed II (1451-1481) and Suleyman the Magnificent (1520-1566) Aydin Sayili writes that the "cultural contact between the Ottomans and Europe had reached its peak and was especially lively in Istanbul. Several Italian painters and men of letters are known to have visited Istanbul and to have stayed there for periods of different lengths. Indeed, Istanbul with its active commercial dealings especially in maritime trade and its thriving Venetian, Genoese, and Ragusan colonies, was a metropolis suited to traffic in ideas and cultural contact between the East and the West. It was itself a foremost representative and repository of Islamic science and culture. The European mathematicians Mordecai Comtino (d. 1478) and Elia Misrahi (1456-1526) - were well familiar with the Ottoman capital, and, in fact, both died there. So it is that the Turkish-Islamic World in general and the city of Istanbul in particular served efficiently as a fountainhead and a vehicle for the transfer of a great deal of knowledge to Europe" (Aydin Sayili, "Turkish Contributions to Scientific Work in Islam", Foundation for Science Technology and Civilisation, September, 2004, 15).

Our approach in this research is, thus, to investigate the civilisational influences across European boundaries in the fifteenth century and to do that based on the study of the foundations of Qushjī's astronomical works. Such a study can help us unravel the new conceptual structure of astronomy according to the emerging constructivist way of the *mutakallimūn*. It is specifically believed that Qushjī's elucidation on constructive semantics in his works on *ʿilm al-waḍʿ* (science of linguistic positing), as well as his philosophical discussions on mental existence (*al-wujūd al-dhihnī*) in his *kalām* work, could reveal more about the new program of science associated with the developments of the constructivist project of later Ashʿarite *kalām*. Qushjī indeed seems to have completed this project and to have turned it into a comprehensive theory of *a priori* knowledge to serve as a new foundation for astronomy and mathematics. Therefore, in tracing this history of the philosophy of *kalām*, a historian of philosophy and science can discover how constructivism in the fifteenth century came to replace Aristotelian realism as a foundation for a new mathematical practice with its associated astronomical and physical sciences.

## 1.2 ʿALĀ'UDDĪN ʿALĪ QUSHJĪ: THE ASTRONOMER AND THE FOUNDATIONAL SCHOLAR

ʿAlā'uddīn ʿAlī Qushjī belonged to the fifteenth century, a very critical period in the history of the formation of Muslim societies in Southeastern Europe, especially the pedagogical development of the higher learning colleges in the city of Constantinople under the Ottomans. According to Ekmeleddin Ihsanoglu[10], "no doubt the most notable scientist of [Sultan Mehmed II's] period is Ali Kuscu [Qushjī]"[11]. In recent times, both

[10] Ekmeleddin Ihsanoglu et al., *An overview of Ottoman Scientific Activities* (London: Foundation for Science and Technology and Civilisation, no. 629, 2006), 7.
[11] Ihsanoglu continues, "He [Ali Kuscu] wrote twelve works on mathematics and astronomy. One of them is his commentary on the *Zīj-i Ulug Bey* in Persian. His two works in Persian, namely *Risālah fil-Hay'a*

Columbia University's Saliba[12] and McGill's Ragep[13] have each published an astronomical work by Qushjī. But apart from brief coverage on Qushjī's *kalām* in relation to causality[14] and some other non-astronomical references in Arabic on his exposition of mental existence (*al-wujūd al-dhihnī*)[15], his scientific foundations and *kalām* have not been systematically studied in relation to his constructivist theory of *a priori* knowledge[16] and his foundations of science, nor have the two themes of scientific foundations and astronomy been studied as interconnected subjects in the works of Qushjī despite their direct conceptual relevance to one another. It is believed that this gap is mainly due to Qushjī being rediscovered only recently in astronomical and academic circles.

In the last decade, there have been a few brief biographies and various other manuals written predominantly in Turkish[17] indicating a recent rise of interest in Qushjī's persona and works in Turkish culture. But to better understand what is already known about Qushjī as a scholar, we can quote from the few comments that we can find scattered across various biographical and scientific sources. According to Abā Zayd,

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(Treatise on Astronomy) and *Risālah fil-Ḥisāb* (Treatise on Mathematics) were taught in the Ottoman Madrasas. He rewrote the two works in Arabic with some additions under new titles, *al-Fatḥīyah* (Commemoration of Conquest) and *al-Muḥammadīya* (the book dedicated to Sultan Mehmed II), respectively" (Ibid.).

[12] George Saliba, "Al-Qushjī's Reform of the Ptolemaic Model for Mercury", *Arabic Sciences and Philosophy*, vol. 3 (1993): 161-203.

[13] F. Jamil Ragep, "'Alī Qushjī and Regiomontanus: Eccentric Transformations and Copernican Revolutions", Journal *of the History of Astronomy*, vol. 36, no. 4 (2005), 359-371; F. Jamil Ragep, "Copernicus and His Islamic Predecessors: Some Historical Remarks", *History of Science*, vol. 45 (2007): 65-81; F. Jamil Ragep, "Freeing Astronomy from Philosophy: An Aspect of Islamic Influence on Science", *Osiris*, vol. 16 (2001): 49-71.

[14] He translated pages 186 and 187 of *Sharḥ al-Tajrīd* from a Persian lithograph manuscript copy in his article *Freeing Astronomy from Philosophy* (note 12).

[15] For example, Sayyid Kamāl al-Ḥaydarī, *Madkhal ilā manāhij al-maʿrifah ʿinda al-Islāmīyīn* (Iran: Dār Faraqid, 1426), 45; Aḥmad ibn Muṣṭafá Ṭāshkubrīzādah, *al-Shuhūd al-ʿaynī fī mabaḥīth al-wujūd al-dhihnī* (Cologne: Manshūrāt al-Jamal, 2009).

[16] It should be noted that in this study the term constructivism and its variations is used to describe the epistemological justification for *a priori* knowledge.

[17] Yavuz Unat, *Ali Kuscu: cagini asan bilim insane* (Istanbul: Kaynak, 2009); Yavuz Unat, *Mir'atul-ʿalem, Evrenin aynasi: Ali Kuscu'nun Fethīye adli eserinin cevirisi* **(**Ankara: T.C. Kultur Bakanligi, 2001); Musa Yildz, *Bir dilci olarak Ali Kuscu ve Risale fīl-istiare'si* (Ankara: T.C. Kultur Bakanlgi, 2002).

for example, in terms of theological orientation, "[Qushjī] is recognised among the highest esteemed Ashʿarite scholars"[18], and he further clarifies that "we can notice his defence of Ashʿarite opinions within the details of his *Sharḥ al-Tajrīd* [*Commentary on Abstracting Kalām*]". Furthermore, Aḥmad ʿAfīfī in his introduction to the edited version of Qushjī's *ʿUnqūd al-Zawāhir fī al-Ṣarf* (*The Chain of Radiant Gems in Morphology*) divides Qushjī's scholarly life into three phases. The first phase is his early life in Samarqand under the Timurid rule. The second is the period he spent among the Turkic kingdoms in Transoxiana (*bilād mā warā' al-nahr*) due to the political unrest at the time, and the third period being under the Ottoman Sultanate during the rule of Mehmed II al-Fātiḥ[19]. Cengiz Aydin also reports that "Muhammad [Mehmed] II took him to the campaign of Bashkent, 878/1473, in the aftermath of which Qushjī was appointed to the Ayasofia Madarasa"[20]. Qushjī was thus associated first with the Samarqand Observatory and later with the scientific community of Constantinople where, at the invitation of Sultan Mehmed II, he assumed the Professorship Chair in Astronomy and Mathematics at the College of Ayasofia bringing forward synergy to the studies of mathematics and astronomy in Constantinople in the late fifteenth century[21].

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[18] ʿAlī ibn Muḥammad Qūshjī, Ṣābir ʿAbduh Abā Zayd, *Min al-Turāth al-Islāmī : Sharḥ al-Qūshjī ʿalā Tajrīd al-ʿaqā'id lil-Ṭūsī " mabḥath al-ilāhīyāt"* (Al-Iskandarīyah: Dār al-Wafā' li-Dunyā al-Ṭibāʿah wa al-Nashr, 2002), 22.

[19] ʿAlī Qushjī, *ʿUnqūd al-Zawāhir fī al-Ṣarf*, ed. Aḥmad ʿAfīfī (Al-Qāhirah: Dār al-Kutob al-Masrīya, 2001), 24-25.

[20] Cengiz Aydin, "Ali Kuscu Diyanet Vakfi Islam Ansiklopedisi", *DIA*, vol. 2 (n.d.): 408-10.

[21] The influence of ʿAlī Qushjī can be seen in the charter of the *madrasah* colleges of Sultan Mehmed II, which set their framework, and which entailed that the rational sciences are to be taught along with religious studies. It is possible to observe this influence after the period of Mehmed II up until the time of the Suleymaniye *madrasas*. In the Fātiḥ Teskilāt Kanūnnāmesi (legal code), when one examines the organization of Ottoman madrasas one observes that the first three are referred to under the names of *Ḥāshiyat al-Tajrīd*, *Miftāḥ* and *Talwīḥ*. These names were taken from the titles of the main textbooks used in these madrasas. The *Ḥāshiyat al-Tajrīd madrasah* takes its name from the fact that the main textbooks used there were commentaries on Ṭūsī's *Tajrīd al-Kalām*. These include appendices on the old commentary written by al-Isfahānī's (d. 1345-46), as well as Qushjī's own new commentary. (Kātib Celebi, *Kashful Zunūn ʿan Asāmil-Kūtūbi wa al-Fūnūn*, 2 vols., ed. Serefeddin Yaltkaya and Kilisli Rifat Bilge (Istanbul: n.p., 1941-1943), vol. 2: 1762-1768).

Qushjī was a prolific multidisciplinary writer and a scholar of 'unity of knowledge'. He authored many works in numerous fields[22]. Consequently, more than 270 unique manuscripts authored by Qushjī can be found in Turkish Manuscript Libraries[23] alone with 43 different titles; broken down as follows: 7 different works in theology and jurisprudence; 13 in astronomy and mathematics[24]; and 24 in Arabic grammar, linguistics, and other literary works. His *magnum opus* in Islamic science is known as *al-Sharḥ al-Jadīd* (*The Novel Commentary*), which was his commentary on Ṭūsī's text, *Tajrīd al-Kalām* (*Abstracting Kalām*). It is noteworthy that a Latin translation of two of Qushjī's scientific works, the *Tract on Arithmetic*[25] and *Tract on Astronomy*[26], were published by John Greaves[27] in 1650[28] with the noted authorship of 'Shah Koshgius'.

[22] Cengiz, 408-10.
[23] These numbers are based on the author's search in the listed electronic catalogues of the Turkish Manuscript Libraries.
[24] The 13 titles are as follows (in Turkish transliteration): (1) *Risâle fi'l-Fethîye*; (2) *Risālah fī hall ishkal al-muʿaddil lil-masir li-ʿutarid*; (3) *Risālah fī anna aṣl al-khārij yumkin fī al-suflayayn*; (4) *Risâle-i Hey'et*; (5) *Risâle der Hey'et*; (6) *Risâle-i Hey'e ve Hisâbı Ehl-i Hind*; (7) *Haşiye Ala Fethîye*; (8) *Fethīye fī marifeti'l-evkati ve's-saat*; (9) *Şerh-i Zîc-i Uluğ Beg*; (10) *Risâle fî İhtilâfî'l-Metali*; (11) *Mirkâtü's-Semâ*; (12) *Er-Risâletü'l-Muhammediye fi'l-Hisâb*; (13) *Er-Risâletü'l-Fethîye fi'l-A'mâli'l-Ceybiye.*
[25] This is a translation of the treatise *al-Risālah al-Muḥammadīyah fī al-Ḥisāb*.
[26] This is a translation of the treatise *al-Risālah al-Fatḥīyah fī al-Hay'a*. This work was originally in Persian and, given the evidence of the extant manuscripts, quite popular. It was translated by Qushjī himself into Arabic and dedicated to Sultan Mehmed, the Conqueror (al-Fātiḥ) of Constantinople (Ihsanoglu et al in note 2, p27–35).
[27] John Greaves (d. 1652) is an English mathematician and astronomer. He was the Savilian Professor of Astronomy at the University of Oxford. He travelled to Constantinople (1638), Rhodes, Egypt, and other parts of the eastern Mediterranean, where he collected a considerable number of Arabic, Persian, and Greek manuscripts ("John Greaves", *Encyclopædia Britannica*, 2011). Greaves quotes Aly/Koshgy in the fourth part of a work published in 1650 *Ali Kushgii de terrae magnitudine & sphaerarum coelestium a terra distantiis*. Greaves quotes from the *Risālah dar ʿilm al-Hay'a* by drawing from a manuscript in his own collection, containing two works by Qushjī: "Tract on Arithmetic" (*Risālah dar ʿilm al-Ḥisāb*), ff. 1-31. "Tract on Astronomy" (*Risālah dar ʿilm al-Hay'a*), ff. 32-65. In his "Elementa Linguae Persae", Greaves illustrates his Persian language with a quotation from 'Shah Koshgius' (Raymond Mercier, "English Orientalists and Mathematical Astronomy" in *The 'Arabick' Interest of the Natural Philosophers in Seventeenth-century England*, edited by G. A. Russell (Leiden: Brill, 1994), 162.
[28] Ibid.

## 1.3 QUSHJĪ'S FOUNDATIONS OF SCIENCE: RESEARCH QUESTIONS

The transformation in the scientific foundations of mathematics, from a classical Greek form in which mathematics is less concerned with quantifying natural phenomena, to a more modern form in which mathematics is used to manipulate quantifications of natural objects, is based on the understanding of contingency in nature - away from any assumptions of causal necessity. This transformation to quantification appears within the discourse of *kalām* that had pushed Aristotelian natural philosophy and its affiliated *falsafah* more and more to the fringes, until philosophy itself was freed from Aristotelianism. In fact, the later *mutakallimūn* (i.e. thirteenth century onwards) began speaking of the movement of celestial objects being within the testable or experimental sciences (*al-ʿulūm al-tajrībīyah*) that is classified as part of an involuntary or obligatory knowledge (*al-ḍarūrīyāt*). By devising such a solution to the rejected Aristotelian theory of knowledge that was grounded in the idea of necessary causality, they were in fact extending the common position of the early *mutakallimūn*, including al-Bāqillānī (d. 1013) and al-Ghazālī (d. 1111) who had insisted on an epistemology that secures the possibility of the Prophetic miracle as an extraordinary occurrence (*khariq lil-ʿādah*), and thus paving the way for the contingent modality of the natural world.

This study, therefore, begins by analysing how *kalām* scholars reconciled their *kalām* with their scientific program based on developments in the semantics of the new emerging discipline of *ʿilm al-waḍʿ* as a science of positing expressions for meaning, and which had begun to supplant formal logic in association to the theory of knowledge. On the role of *kalām*, ʿAḍud al-Dīn al-Ījī (d. 1355) and his commentator al-Sayyid al-Sharif al-Jurjānī (d. 1413), who greatly influenced early Ottoman scholars, had described how *kalām* maintained its position as a general methodological base for other Islamic disciplines by systematising *kalām*'s own epistemology to sufficiently keep it

as the source and framework of these disciplines[29]. By taking *kalām* as a common foundation for scientific disciplines, the *mutakallimūn* tried to integrate philosophy and science into the empirical contingent world. On this theme, Muḥammad Bāsil al-Ṭā'ī[30] asserts that "*daqīq al-kalām*[31] has much to offer the subjects of natural philosophy and the contemporary philosophy of physics on the conceptual level[32]."[33]

Indeed something new did happen in *kalām* in the fifteenth century, as a result of such earlier development, and it was represented by what Qushjī himself referred to with his work on *Sharḥ Tajrīd al-Kalām* (*Commentary on Abstracting Kalām*) as being of a new conception, and which he named *The Novel Commentary* (*al-Sharḥ al-Jadīd*) despite there being numerous other supercommentaries by that time that were commentaries on Isfahānī's (d. 1345-46) earlier commentary including Jurjānī's gloss *al-Ḥāshiyah ʿalā Sharḥ al-Tajrīd*. Qushjī insisted that his work on the *Tajrīd* was of a new framework and methodology that rendered it a new classification (*taṣnīf jadīd*)[34]. Saliba emphasised this newness with Qushjī's work by remarking that "Qushjī ... was in no way connected to the *Tadhkirah* tradition"[35] of Ṭūsī's Maragha Observatory given that he saw himself belonging to a new mathematical school that stems from his new

[29] ʿAḍud al-Dīn al-Ījī, *Kitāb al-Mawāqif fī ʿIlm al-Kalām*, ed. ʿAbd al-Raḥmān ʿUmayra (Bayrūt: Dār al-Jīl, 1997), 43-45.
[30] He is a professor of physics at Yarmouk University in Jordan (PhD, University of Manchester, UK, 1978). His latest book is entitled '*Daqīq al-Kalām: al-ru'yah al-Islāmīyah li-falsafat al-tabīʿah*' (Jordan: ʿĀlam al-Kutub al-Ḥadīth, 2010).
[31] Al-Ashʿarī's *Maqālāt Islāmīyīn* is divided into two sections "Jalīl *al-Kalām*", which deals with Attributes of God, meaning of Faith, guidance and misguidance and other related matters, while the second section is on "Daqīq *al-Kalām*" and it deals with the issues that are generally dealt with in natural philosophy, such as atoms and accidents, causality, corporeal bodies, space (*taḥayyuz*), time, etc.
[32] Indeed, the *Kalām Cosmological Argument* devised by William Craig is just one contemporary example in a whole field of ideas, concepts and arguments that can be utilized by the modern philosophy of science.
[33] Based on a talk given at the Institute of Arab and Islamic Studies, University of Exeter (UK) on 26 January 2005 entitled *Daqīq al-Kalām: The Islamic Approach to Natural Philosophy*.
[34] Qushjī also has *Sharḥ al-zīj al-Jadīd*, which indicates the 'newness' of the Samarqand *zīj* as opposed to the Maragha *zīj*, two centuries earlier.
[35] George Saliba, "A Sixteenth-century Arabic Critique of Ptolemaic Astronomy", *Journal of the History of Astronomy*, vol. 25 (1994): 34.

framework for science. This distinction in astronomical tradition in fact supports Qushjī's own classification of his commentary on Ṭūsī's *Tajrīd* being of a new pattern of thought. Indeed, Qushjī continued Ghazālī's volitional criticism of Peripatetic philosophers and their Aristotelian framework by further developing his response to causation (a topic we explore in Chapter Two on *Constructivist Origins*), and by also extending its application onto a new philosophy of science that can be labelled, as we later explain, as being 'subjectivist' or 'conceptualist'.

By modeling the mental process by which individual meanings are assigned to vocal expressions (auditory or visual), conceptual positing or *waḍʿ* becomes a representation of how expressions are understood in the mind by way of mentally considering a universal concept. Qushjī, who made significant progress in constructive semantics, brought over his general method of understanding, as we later see in Chapter Three, and in particular his individuation theory from *ʿilm al-waḍʿ* into *kalām*'s various investigations on mental existence and its diverse empirical applications, such as the motion of the celestial objects and other astronomical inquiries. Crucially, this breakthrough in conceptualist methodology of knowledge opened the way for a constructive astronomy and a new phase in scientific discovery that today stands as a strong contender for having supplied the trigger for the various events in the history of science since the fifteenth century. A core emerging idea with constructive mathematics as a universal language of symbols is the belief that mathematical statements have validity because they are drawn from linguistically-consistent systems of signification and meaning whose rules are drawn up for common human understanding. At the center of this issue is, therefore, the concern about the justification for mathematising the natural world through the construction of mathematical models.

The implications from constructive semantics on constructive foundations are made clearer in Qushjī's selected work on constructive *kalām*. In this dissertation we, therefore, focus on both the crucial role that Qushjī plays in the development of constructive semantics as well as the role he plays in the development of constructive or universal *kalām*. Our investigation covers three texts; two on constructive semantics studied in Chapter Three and one major text on constructive *kalām* studied in Chapter Four. The two treatises in semantics are: (1) *Sharḥ al-Risālah al-Waḍʿīyah* (*Commentary on the Treatise on Linguistic Positing*) [Manuscript] and (2) *ʿUnqūd al-Zawāhir fī al-Ṣarf* (*The Chain of Radiant Gems in Morphology*) [Al-Qāhirah: 2001], and the major *kalām* text is (3) *Sharḥ Tajrīd al-Kalām* (*Commentary on Abstracting Kalām*)[36] [Manuscript].

On the former two semantics treatises ʿAbd al-Malik al-Fatānī (d.1913-4)[37], a prominent scholar of Makkah and Madīnah asserts[38], "Linguistic topics ... have their principles in the study of *waḍʿ* and its texts range in their benefit with the best source as far as I know is *ʿUnqūd al-Zawāhir* and its commentary as well as *Risālat al-ʿAḍud* (i.e. the aforementioned *al-Risālah al-Waḍʿīyah*)"[39]. On the other hand, *Sharḥ Tajrīd al-Kalām* (*Commentary on Abstracting Kalām*) is a text that contains Qushjī's constructivist philosophy, which is studied here for the foundations of his constructive astronomy. It was written as a commentary on Naṣir al-Dīn al-Ṭūsī's (d. 1274) *Tajrīd*

[36] This text which Qushjī dedicated to Timurid Sultan Abū Saʿīd secured him an impressive gift of 50,000 Dinars quickly becoming an object of discussion in the scholarly circles indicating that the intellectuals of the time were aware of its implications. See Bakharzi ʿAbd al-Wāsiʿ, *Nizami-yi Maqāmāt-i Jami*, edited by Najīb Māyil Harāwī (Tehran: Nash-i, 1999), 72-74.

[37] ʿAbd al-Malik al-Fatānī d.1913-4 is a prominent Ḥanafī scholar of Makkah and Madīnah. He was a Qāḍī in Makkah.

[38] He states this in *Sharḥ ʿIqd al-La'āli' fī ʿIlm al-Waḍʿ* (Al-Qāhirah: al-Matbaʿah al-ʿĀmirah al-Sharqīyah, 1306) found at Princeton university. This manuscript has been digitised by Google and is available online.

[39] *Innal-mawdūʿāt al-lughawīyah ... mabādiʾuhā mabāḥith al-waḍʿ wa kutubihi mutafāwitah fil-nafʿ wa inna aḥsanahā fimā aʿlam ʿUnqūd al-Zawāhir wa sharḥihi wa risālat al-ʿAḍud wa qad kuntu ibbāna al-taḥṣīl antakhibu minhā* (*Sharḥ ʿIqd al-La'āli fī ʿIlm al-Waḍʿ*, 2)