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IBN SINA'S OBSERVATION OF A TRANSIT OF VENUS IN 1032

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Abstract: It has been said that the Venus transit of 24 May 1032 was observed by Ibn Sina and recorded among his written output. This was critically evaluated by Goldstein (1969), who demurred on the claim. However, Kapoor's (2013) thorough review has shown that Ibn Sina could well have observed this event, giving rise to an ongoing interest in the geocentric versus heliocentric discussion, such as was picked up by Nasr ad-Din Tusi and others. This eventually culminated in the general acceptance of the Copernican world-system. We reconsider the special circumstances of the reported discovery and show that Ibn Sina indeed could have observed the event, with a discussion of its significance along the way to a Sun-centered world.

Özet: 24 Mayıs 1032 tarihli Venüs geçişinin İbni Sina tarafından gözlendiği ve bu bilginin kendisinin yazılı ürünleri içinde bulunduğu not edilmektedir. Bu iddia Goldstein (1969) tarafından kritik edileren değerlendirilmiştir. Diğer taraftan, Kapoor (2013) tarafından yapılan ayrıntılı gözden geçirmede, bu olayın İbni Sina tarafından gözlenmiş olabileceği sonucuna varılmakta, daha sonra bu gözlem bilgisi Nasrettin Tusi ve diğerleri tarafından da ele alınarak, yer-merkezliye karşı güneş-merkezli evren tartışmaları nedeniyle, ayrı bir ilgi ve tartışmanın konusu olmaktadır. Bu durum giderek, Kopernik dünya (evren) sisteminin genel kabulü ile sonuçlanmaktadır. Bu çalışmada, kayda geçirilen keşfin/gözlemin yapıldığı özel koşulları göz önüne alınarak, Sina'nın olayı gözlemiş olduğu gösterilmekte ve bunun yer-merkezli bir dünyadan Güneş-merkezli bir dünyaya dönüşümündeki önemi tartışılmaktadır.

Keywords: Ibn Sina, Venus Transits, Copernican world view

1 TRANSITS OF THE INNER PLANETS

Transits of the planet Venus across the solar disk occur relatively rarely on human timescales, and attract a widespread interest when they do occur. This was experienced by the present authors during the transits of 2004 and 2012. On the latter occasion, the event was succesfully observed by the camera obscura method (Özel, 2012; Özel, Solmaz and Budding, 2012; Özel and Saygaç, 2016). The procedure was known since antiquity and, although involving some degree of planning, could have been used by Classical and Medieval astronomers in the contexts we consider in what follows.

Reviewing the proceedings of IAU Colloquium 136 on *Transits of Venus* ..., Kurtz (2005) noted the great stimulus to various branches of astronomical science occasioned by the event. These included reflections from historical accounts of how scientific challenges were responded to, and the implications of such responses for ongoing developments in data precision and interpretation. The possible Mayan observations of a transit of Venus in the thirteenth century was examined by Trejo and Allen (2005) at the same conference. While clearly of historical significance, Mayan interest around Venus arises from a different cultural context than in testing the classical Ptolomaic model of planetary motions.

The possibility of transits of Venus and Mercury (their orbital passages in front of the solar disk) was discussed by Ptolemy in the Book IX of his *Almagest* (Toomer, 1984: 419) when perfecting the Earth-centered world model in the second century AD. Such modelling should allow predictions of when transits occur (Neugebauer, 1975), although, in fact, we have no record of any corresponding observation. Ptolemy referred to many astronomical observations in compiling *The Almagest* that usually include the following: name of observer, location of the observation, date of the event, circumstantial references from the sky at the time. For example, in discussing the length of the year in Book III, Ptolemy refers to Hipparchus' observations, from Rhodes, of the solar eclipse that occurred in year 32 of the third Calliipic period, when Spica preceded the autumn equinox by 6½°. Ptolemy noted, however, that such careful work of Hipparchus contained no mention of a transit of Venus (Toomer, 1984: 421).

In the Introduction to Copernicus' *De Revolutionibus*, Wallis (1993) makes the point that the Ptolemaic model for the orbit of Venus, being conventionally 'below the Sun', gives rise to some awkward questions about the scale of the implied changing appearances of the planet. Ptolemy admits that there were some models that allowed Venus and Mercury to pass beyond the Sun. It is implicit in the arguments that these planets are on the same deferent as the Sun, so that the Ptolemaic model reduces to a heliocentric one if the epicycles are also concentric with the solar one. Copernicus regarded the planets as opaque and owing their brightness, like the Moon, to the reflected light of the Sun.

In more recent times, tables computed by Espenak (2004), and others, provide details of the transits of Mercury and Venus between 2000 BC to 4000 AD. These show that none of the prominent figures of astronomy and science during the Islamic Mediaeval Renaissance (from about the eighth to the fifteenth centuries AD) would have had much chance to observe inner planet transits directly. The main points—assuming that we are dealing with only direct naked eye observing—are that the inferior conjunction has to be close to a node (within the 'transit zone' of about 4° in longitude) for a transit to be observable from the Earth. Then, even if that relatively rare condition is satisfied, the Sun's disk would probably be too bright to allow the small black planetary disks to be detected. Thus, Mercury, with only 1/175 of the apparent diameter of the Sun, though having more frequent solar crossings than Venus, is not visible to the unaided eye (Fitzgerald, 1953).

On the other hand, large sunspots subtending more than ~40″ are not that infrequently seen with the unaided healthy eye, particularly towards sunset when the glare is reduced, and especially if there is some haze (Keller and Friedli, 1992). Venus, with about 1/30th of the Sun's angular size at inferior conjunction, can then be made out against the solar photosphere as a distinct black circular spot. Although there are several reports of Medieval Islamic scholars observing dark-spot phenomena on the Sun, they were essentially dismissed as sunspots by Goldstein (1969) after close review. This was on the basis of timing and location mismatches, given the known orbital facts.

One exception, however, concerns the claim by the eleventh century polymath Ibn Sina (980–1037) that he observed a transit of Venus. Ibn Sina (also known as Avicenna) was more famous for his treatises on medicine, philosophy and general sciences, during his own time and through the Middle Ages. But, interestingly, the following note was found in his translated version of *The Almagest*: "I affirm that I saw Venus as a black dot against the Sun's disk." The inscription appears in Ibn Sina's own copy of *The Almagest* in the Bibliotheque Nationale de France (code: BnF Arabe 2484)—see Figures 1 and 2—and is referred to in other texts by him and by later scholars of the Islamic Renaissance. The matter has been comprehensively reviewd by Kapoor (2013), who demonstrated, on the basis of more recent data and calculations (cf. Espenak, 2004), that Ibn Sına *could* have observed the one transit of Venus that occurred during his lifetime.

2 THE TRANSIT OF VENUS OF 24 MAY 1032

Kapoor (2013) confirmed that the transit of Venus that occurred on 24 May 1032 would have been visible from Isfahan close to sunset, and with a better chance from Hamedan. This is where Ibn Sina had spent some of his earlier years and where he returned towards the end of his life. Although simple geometry applied to the circumstances indicates that the Venusian ingress would have only just started as the Sun set at Isfahan (see Figures 3 and 4), inclusion of the effects of atmospheric refraction and terrrestrial elevation of the viewing location would have allowed the second contact to be completed before the Sun completely sank from view. Conditions are more favourable from Hamedan, where sunset would have been 17 minutes later than at Isfahan (Espanak, 2004). Granted, then, that Ibn Sina could have observed the start of the transit, the pertinent questions that arise are:

(1) Would this have been a fully planned and directed observation, such as those presented by Ptolemy in *The Almagest*?
(2) If so, why are there no supporting details available?
(3) If not, how did Ibn Sına know that he was seeing a transit of Venus?
(4) Assuming that he did know that the observation was that of a transit of Venus, to what extent would his interest have been sufficiently aroused to bring about his brief declaration? In other words, what is the scientific motivation or significance of the statement?
(5) Apart from Ibn Sina, we can ask if anyone else witnessed this rare event in 1032?

Ibn Sina was known as 'the great teacher' of his time. Indeed, he was regarded by some as the second greatest teacher after Aristotle (Nogales, 1980). So, having an illustrious reputation to maintain, with respect to Question 1 we may follow Kapoor (2013) in supposing that it is at least feasible, taking into account Ibn Sına's familiarity with *The Almagest*, that he would have looked into the details of upcoming conjunctions of Venus. On the other hand, Kapoor's inclusion of the Ptolemaic model's prediction of a miss for the syzygy in 1032, togeth-

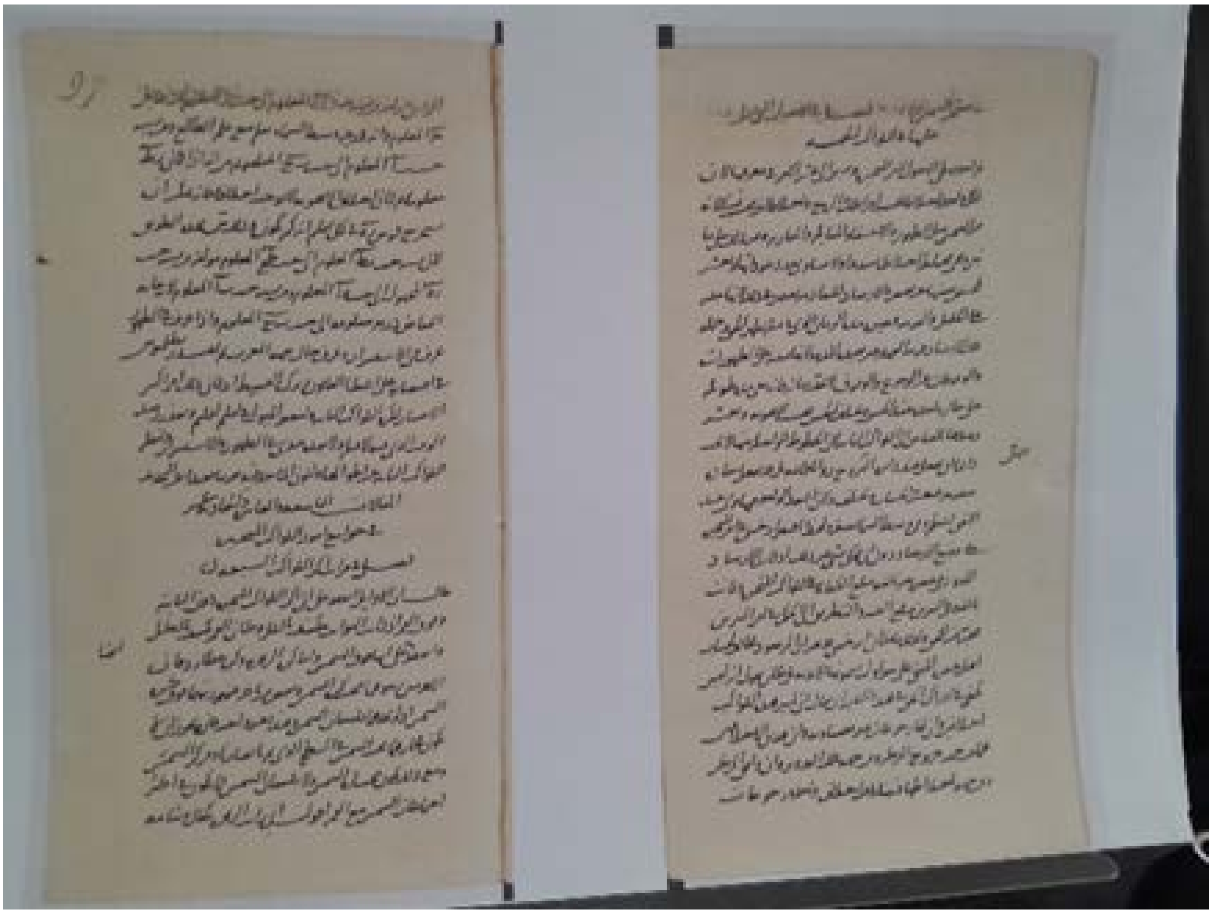

Figure 1: Ibn Sina's text, folio page 97a,b in his book **(**starting from last line in 97a **(**left side**)** and first line in 97b (right side) which reads "I affirm that I saw Venus as a black spot against the Sun's disk." (our English translation). For further details, see Figure 2 below, and Appendix 1.

er with Ibn SIna not being *primarily* an astronomer, casts doubt on the extent of preparation and planning (see also Neugebauer, 1975). The question of verification at the following transit, which would have been on 22 May 1040, might have been anticipated after the success in 1032, but did not materialize owing to the demise of Ibn Sina in 1037.

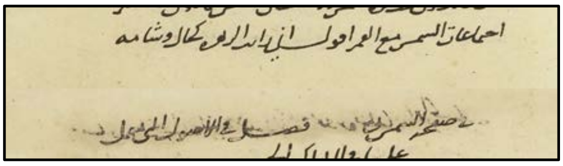

Figure 2: Close-up of the relevant lines in Ibn Sina's text.

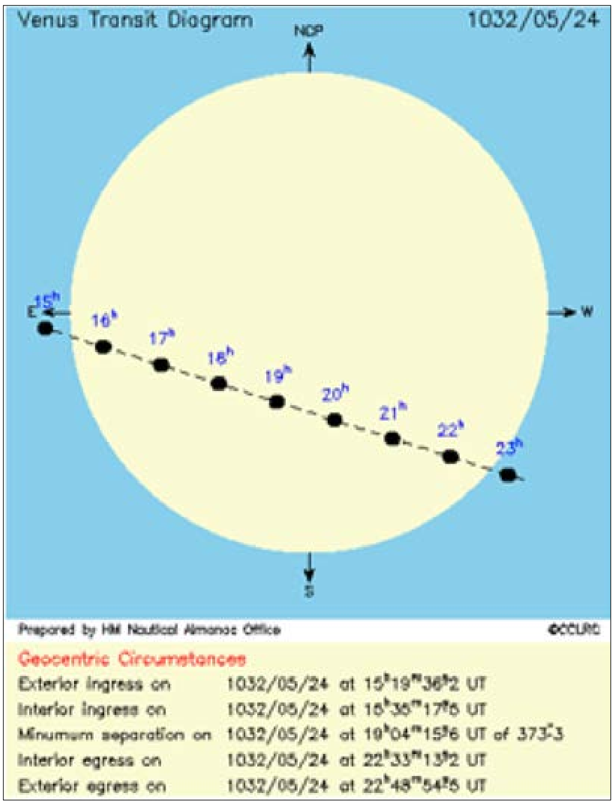

Figure 3 (right): The geocentric circumstances of the transit are shown in this figure from Espenak (2004). During the transit, the diameter of the Sun is 31.5′ (1888.6″) and that of Venus is 0.96′ (57.6″). The duration of the ingress is about 15 minutes. The minimum separation between the centre of the solar disc and Venus was 6.2′ (373.3″). The complete transit lasted about seven and a half hours. All timings are given in Universal Time (UT). (courtesy: Espenak, 2004).

Figure 4: The red arrows in this map show the cities that Ibn Sina lived in or travelled to during his lifetime. During the last 15 years of his life he occasionally met El Biruni and they discussed problems of mutual interest. The blue lines show El Biruni's recorded travels. Ibn Sina was living in Isfahan, Iran (the prominent red circle) at the time of the 1032 transit of Venus. Added to the map are sunset lines on the day of transit. Line 1 passes near Shiraz and was derived by Espenak (2004), when the ingress phase of the transit would have been observed shortly before sunset. On the other hand, line 2 (to right of line 1) was calculated by Marsden, and the transit would not have been visible to the east of this line. Although there is a slight difference between these two lines, both would have allowed Ibn Sina to observe the transit from Isfahan (after Strohmaier, 2006).

The absence of further details (Question 2) could be covered by Kapoor's recall of the political turmoil affecting north-west Iran in the late 1030s. Ibn Sina's patron Alā' ad-Dawla was not backed by the rival Ghaznavid party. According to the biographer Afnan (1958), the Ghaznavids overran Isfahan in 1030, wherupon Alā' ad-Dawla fled, accompanied, it may be presumed, by Ibn Sina. It was then that the latter's house was plundered and his library carried off to Ghazna, only to be destroyed about a century later by the invading Ghūrīd Turks. Although different sources contain different details, the episode can be understood to have dealt a serious blow to Ibn Sına's general state of health, from which he never fully recovered.

The answer to Question 3 follows from a positive respone to Question 1, but that is not necessarily the only solution. The case for a serenpendipitous discovery was raised by Kapoor, but downplayed as the carefully planned observation favoured by that author explains that Ibn Sina, in his note, clearly identifies Venus. However, after noticing the event and 70 days later observing the western elongation of the planet, Ibn Sina, with simple but justifiable reasoning, could have easily deduced the appropriate cause of the black spot on the solar disk.

Even if the answer to Question 1 is negative, it does not rule out that Ibn Sina came to the realization that he had witnessed a transit of Venus, and that this had a bearing on the Ptolemaic world model adopted by the majority of learned scholars in the first millenium. The difficulties of resolving the sub-solar model for the inner planet orbits with their actual appearances was alluded to by Ptolemy in *The Almagest*. Observation of the eclipse phenomenon at the syzygy forces the issue—an issue that was later adressed by Nasr ad-Din Tusi (Saliba, 2006).

But Question 5 also bears on the whole matter of how we should regard the note in Ibn Sina's copy of *The Almagest*. Where was Ibn Sina's student Al Juzjani during the transit? And a significant point, mentioned in passing by Kapoor, is that the event occurs more or less around the time for the Maghrib, or evening prayer. It seems likely that a great many eyes would, as normal, have been looking at the setting Sun on that evening—wherever the Iranian sky was clear enough! Naturally, even if Ibn Sina was not the first to see the curious black spot, his attention would surely have been brought to it by others.

We should remember here that, since the earliest times, the 24-hr day has started at sunset in the Islamic calendar, which is also noted by Kapoor (2013). In fact, many important mosques retain special attendants (called *muvakkits* i.e., the time-keepers) who are responsible for the timing of 'the day' and daily prayers. Observation of sunset was among their main duties. Such attendants would surely have noticed an unusual 'black spot' near the solar limb and immediately informed the authorities, including Ibn Sina. That is very likely to have been the case, regardless of the extent of Ibn Sina's direct observational activity. In short, we can say with high confidence that had such an eclipse been visible anywhere in the region it would have been reported to Ibn Sina for comment. Ibn Sına presumably knew enough astronomy to recognise the event as occurring exactly halfway between the two elongations of the planet Venus, and could confirm that the phenomenon was indeed a transit of the planet across the solar disk.

The brief note in his book then falls into place as a reminder about a singular experience that caused widespread excitement at the time. The missing details were lost, quite plausibly, in the evacuation from Isfahan during the political unrest of later years.

3 CONCLUDING REMARKS

Kapoor (2013) has made a good case that Ibn Sina could well have observed the transit of Venus in 1032, and although the evidence available to us falls short of an absolute proof, of course it is possible that further evidence may yet come to light. But Kapoor's scenario emphasizes the direct role of Ibn Sina in a single-person operation: that he went through *The Almagest*, and after consulting zij tables identified and then selected the 1032 event for a special observing programme (even though the Ptolemaic model excluded a solar disk transit).

A more likely scenario is that the 1032 transit, visible as a round black spot at the time of evening prayer in north-west Iran, would have been noticed by many persons, not just specialist astronomers. It then becomes very likely that the event would have been brought to the attention of Ibn Sina who was in the general area at the time. We can then reasonably claim that Ibn Sina was the first scientific authority to confirm a transit of Venus as an observed event. Ibn Sina would have used his knowledge of *The Almagest* in giving the natural explanation, as well as bringing to mind the problems that had been raised since antiquity about the appearances of the inner planets.

An important corollary is the development of ideas about the Sun-centered model. Although this had been raised by Ptolemy with reference to the model of Aristarchus of Alexandria (third century BC), it only culminated in 1543 when Copernicus published his revolutionary book. While Medieval Islamic astronomers did not write directly on this theory, it is clear that Ibn Sina's 1032 transit of Venus observation and the work by other Islamic astronomers, including Nasr ad-Din Tusi (1201–1274) and Qutbuddīn Shīrazī (1236–1311)(Kapoor, 2013; Saliba, 2006), influenced the development of the heliocentric theory model.

4 ACKNOWLEDGEMENT

We thank Dr Taha Yasin Arslan for his search to locate Ibu Sina's book and note on the transit of Venus in libraries in Istanbul and on the internet, eventually locating a copy in the Bibliotheque Nationale de France. We also are grateful to the referees for their helpful comments.

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6 APPENDIX 1

Details of Ibn Sina's book and his transit observations are presented below.

6.1 Title of the Book

Summary of the Book of Almagest of Ptolemy by the sheikh Ibn Sīnā.
مختصر كتاب المجسطي لبطلميوس(see Figure 5).
Its Arabic transliteration: "*Mukhtaṣar kitāb al-majasṭī li-batlamyūs taḥrīr al-shaykh Ibn Sīnā*"

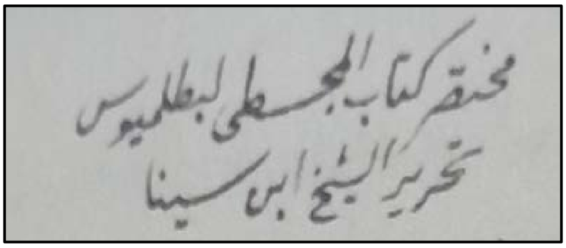

Figure 5: A close-up of the title of the book.

6.2 The Lines About Ibn Sina's Observation of the Transit of Venus

"I say that I saw Venus as a mole on the Sun's disk."
اقول اني رئيت الزهرة كحال وشامة في صفيحة الشمس(see Figure 6).
Its Arabic transliteration: "Aqūl annī raʾaytu al-zuhra kaḥāl wa-shāma fī ṣafīḥat al-shams"

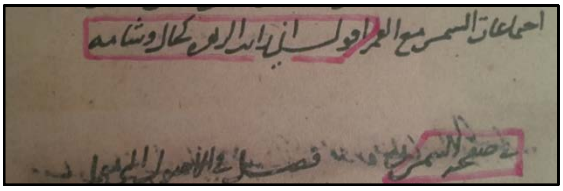

Figure 6: A photograph of the lines in Ibn Sina's translation of *The Almagest* that record his observation of the transit of Venus (indicated by the red marker).

Dr Mehmet Emin Özel was born in Kırcaali, Bulgaria, but his family immigrated to Turkey in 1951 and Mehmet started school in Turkey. He graduated in physics from Middle East Technical University (METU) in 1969 and from the High Teacher's Training School in Ankara, 1974. After receiving his MSc from METU, he went to the NASA-Goddard Space Flight Center (1976) to prepare his PhD thesis in High Energy Gamma Ray Astronomy using SAS-2 gamma ray satellite data, and presented his thesis at the METU Physics Department and got his degree in 1978. He was then appointed as a staff member in the Department.

Later, he visited several laboratories that were committed to gamma ray astronomy. As an Alexander v. Humboldt visiting researcher, he joined the Max Planck Institute for Extraterrestrial Physics (MPE) at Munich, Germany, to work on the ESA's COS-B satellite as a member of the Caravane Collaboration among European laboratories in gamma ray astronomy. He participated in the analysis of the gamma ray observations. He later moved to the Max Planck Institute for Radioastronomy int Bonn and carried out radio observations of the gamma ray sources revealed by COS-B. Later, he was invited to NASA-GSFC as a NASA Fellow, and he worked on the Compton Gamma Ray Observatory between 1986-1989. The discovery of a number of galactic and extragalactic point sources as well as the diffuse structure in the galactic plane and at high latitudes were the main research highlights of the group.

In 1989, Dr Özel moved to the University of Çukurova in Adana, Turkey, where with the help from local sources and some funding from the Alexander v. Humboldt Foundation he established a research center for space sciences and solar energy. Later, he was a Senior Researcher at the TUBITAK Marmara Research Center and worked on satellite remote sensing, image analysis and also in astronomy, participating in the establishment of the TUBITAK National (Optical) Observatory at Antalya, Bakırlıtepe.

He then moved to Çanakkale University (COMU) in 2001, as a Professor and Director of the Graduate School of Science and Engineering. There he met Professor Edwin Budding, the start of a long-term collaboration in several fields. Their joint interests in fields like history of science and the origins of life have continued to the present day, and culminated in several conference presentations and scientific papers, including the present one. Since his retirement, Dr Özel has continued to work from his home in Gebze–Kocaeli, Turkey.

Dr Edwin (Ed) Budding was born in Chadderton, near Manchester, UK, in 1943, where he lived until moving to London to study for his first degree at University College London in 1961. That was in the Astronomy Department of Professor C.W. Allen (renowned for his *Astrophysical Quantities*). This followed up on a deep interest in the subject, developing from early childhood.

After graduation, Ed moved to the Jeremiah Horrocks Observatory (JHO), Preston (now part of the University of Central Lancashire) to work with V. Barocas, particularly on wide-field observations made with the 15-inch Wilfred Hall Astrograph. There was also a focus on public information and education services at the central park setting of the JHO. The astrograph's plates were processed in the measuring laboratory of Z. Kopal's Astronomy Department in

Manchester. In due course, this led to a transfer from Preston to Manchester, where Ed enrolled in the postgraduate course supervised by Professor Kopal, with the topic of close binary stars as a priority.

In this environment, Ed encountered a great wealth of professional experience with visits to leading facilities at home and abroad. In Manchester, he was to meet M. Kitamura of the National Observatory of Japan, and, after completing his PhD in 1972, Ed moved to work with Professor Kitamura, carrying out photometric and spectroscopic observations at Dodeira and Okayama Observatories. In 1974, he accepted a teaching position in Kopal's Department and moved back to Manchester. The Department maintained a good rapport between 'town and gown', cultivated through public lectures, local societies and the Workers Education Authority.

In 1982, Ed accepted a position at Wellington's Carter Observatory, which was then known as the National Observatory of New Zealand, under the direction of Dr R.J. Dodd. This lead to many new experiences in a Southern Hemisphere setting. Public and educational functions of the Observatory were also in view, with a close connection between the Observatory and local and national astronomical societies. Later, after a few years at the former Central Institute of Technology (in nearby Upper Hutt), Ed renewed his main research field on close binaries with another former Kopal student, Professor Osman Demircan, and his astronomy group at Çanakkale in Turkiye (COMU). Ed last returned from working at COMU in 2016.

Ed has been enriched by the multi-faceted experience of following his childhood aspirations, and is grateful to the many teachers, friends, supporters, colleagues, students, general enthusiasts and, of course, family, who enabled this starlit path to materialize.