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Borromini and the New Astronomy:
the elliptical dome

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Abstract. The cosmological view of the universe has frequently been reflected in art and architecture, especially in the cosmological symbolism attached to domed architecture, which relates to the traditional perception of the flat earth covered by the dome of heaven. Examples range from Byzantine churches to the revival of domed architecture during the Renaissance, and the decoration of the domes themselves also often alludes to astronomical symbolism. The reflection of contemporary perceptions of the universe in art developed dramatically during the Renaissance alongside the changing view of the universe, instigated by such thinkers as Copernicus, Kepler and Galileo. While Copernicus challenged the accepted order in his heliocentric system, Kepler further demonstrated that the ordering of the movement in the universe was in fact based on elliptical rather than perfect circular motion. Contemporary with Kepler's writings, the work of the Baroque architect Borromini appears to have been influenced by the enormous changes in world view, cosmology and astronomy of the age. His major architectural works reflect seventeenth century scientific developments and are often based on schemes of mathematical precision. His use of the elliptical dome in preference to traditional classical and humanist precepts, such as the perfection of the circular form, appears to be related to the changing cosmological view and it seems unlikely to be a coincidence that that the predilection for elliptical domes in ecclesiastical architecture comes in at about the same time as Kepler.

Borromini and his architecture
Somewhat eclipsed (to use a suitably astronomical term) by his contemporary and rival Gianlorenzo Bernini, the Italian architect Francesco Borromini (1599–1667) left a lasting imprint on Italian Baroque Architecture of the seventeenth century. Regarded as enigmatic

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and revolutionary in his own time, he was often accused of overthrowing the traditional approaches and rules of classical architecture – an artistic anarchist who replaced the accepted vocabulary with innovation and disorder.[1] Closer examination reveals, however, that mathematical precision underlies his apparently extravagant Baroque schemes and that seventeenth century scientific developments, in particular the enormous changes in world view, cosmology and astronomy, appear to have had a direct effect on his key architectural works.

Borromini's interest in astronomical symbolism and mathematics
The need for architects to be familiar with science and mathematics, including 'astronomy and the theory of the heavens' was emphasized by the Roman architect Vitruvius in his Ten Books of Architecture. Such ideas were enormously influential in Italy in the sixteenth and seventeenth centuries and scientific and mathematical developments in the seventeenth century seem to have appealed in particular to Borromini. Interest in the perfect circular form in the Renaissance derived from Platonic thought and concepts of natural perfection, yet the vocabulary of architecture, including domed architecture, altered radically during the 'Age of Enlightenment' in the seventeenth century. The use of the elliptical dome is a key feature of Baroque architecture (Fig. 1, Fig. 6), yet explanations for the notable preference of architects like Borromini for elliptical rather than perfectly circular or hemispherical domes appear incomplete. The inspiration of developments in astronomy in the seventeenth century challenged many classical and humanist precepts, such as the perfection of the circular form, and it is worth considering whether the predilection for the form of the ellipse by architects like Borromini might have anything relationship with Kepler's view of the structure of the universe.

Domed architecture as image of the cosmos
The idea of architectural domes in religious or spiritual buildings as imitative of natural eye observation of the flat earth covered by the 'dome' of Heaven has a long tradition. The idea is reinforced by cosmic representations on the interiors of such domes from ancient Greek and Roman examples to the proliferation in Christian Architecture. Byzantine architecture in particular reflects the longstanding traditions of Biblical cosmology and a wish to construct and decorate places of worship in an

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[1] Anthony Blunt, *Borromini* (London: Allen Lane, 1979).

imitation of the universe itself.[2] In western Europe, the tradition was very much reinforced, for example, by the cosmic mosaics in the domes of St Mark's, Venice, and the classical and Platonic influences that led to the revival of the symbolism of the circle, and consequent interest in domed architecture in the Renaissance, produced such well known examples as the astronomical frescoes on the dome of the Old Sacristy of S Lorenzo in Florence. Evidence of the interest of artists in the new astronomical developments during the Renaissance, and papal patronage and support for the expression of such ideas in important commissions, has been demonstrated particularly in the work of Michelangelo in the Last Judgment in the Sistine Chapel, where the significance of sun-symbolism and the influence of Copernicus' heliocentric universe has been strongly argued.[3] A similar influence, also with possible official patronage, may be argued for Borromini's use of elliptical domes, which were constructed around the same time that Kepler's theories were developed.

Key works by Borromini
Borromini's churches of S. Carlo alle Quattro Fontane (Rome, 1638-41, Figs 1 and 2) and S. Ivo della Sapienza (Rome, 1642, Fig. 3) involve rather novel and complex geometric designs that are key to the understanding of these buildings. That the meaning of these designs is indebted partly to astronomical ideas may further be confirmed by Borromini's adoption at S. Carlo and S. Ivo of the astronomer's unique interpretation of the cosmos. At S Carlo alle Quattre Fontane (1638-41), mathematical ideas clearly underlie the scheme (drawing Fig. 4 and modern scheme, Fig .5) and the result is a complex structure of elliptic segments that dominates the entire design of the church. The enormous changes in world view, cosmology and astronomy might well have had a direct effect on this work where the plan is based on an intricately evolved geometrical diagram, which appears to attempt construction of the ellipse in a far more sophisticated way than late sixteenth century examples where domes were (rarely) simply elongated along one axis. By contrast, the use by Borromini of the mathematically based or elliptical dome in churches like S Carlo alle Quattre Fontane (1638-41) and by Bernini at S Andrea al Quirinale (1658-70, Fig. 6) are striking in their

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[2] Valerie Shrimplin, 'Domed Architecture: Image of the Universe', *The Inspiration of Astronomical Phenomena II: Malta*, ed. R. White.
[3] Valerie Shrimplin, *Sun-symbolism and Cosmology in Michelangelo's Last Judgment* (Missouri: Truman State University Press, 2000).

mathematical basis. Not simply rectangles with rounded corners, the construction at S Carlo for example is based on a specific mathematical scheme. A compressed elliptical dome rests on a stretched Greek cross, a tense form suggesting suppressed energy as does the facade of San Carlo (1665-1667), based on a complex system of convex and concave forms (Fig. 7). At S Ivo della Sapienza, Rome (1642, Fig. 3 and Fig, 8, detail) Borromini totally transforms the traditional central church plan by using a star hexagon plan extending into the dome. Borromini's S. Giovanni in Laterano (1650) also reflects the architect's interest in current mathematical problems.

Johannes Kepler (1571-1603)

Following on the work of Copernicus and Tycho Brahe, and in an attempt to explain anomalies in their hypotheses in his early work, the *Mysterium Cosmographica* (1596), Kepler looked to the concept of the perfect regular nested solids as the basis for the disposition of the planets, as derived from Plato's *Timaeus*. Kepler started to question the ancient basis of astronomy founded on circular orbits and began to consider the ellipse at the basis for his view of the universe and its mechanics. He had realised that the universe did not work on perfect circular motion but rather that the orbits of the planets were elliptical, with the sun placed at one of the foci, as explained in his first two Laws (in his treatise on Motion of Mars, 1609) and third Law (in Harmony of the World, 1619). These views might well have had far reaching influence on the cosmological symbolism of spiritual architecture, and particularly the work of the innovator Borromini. In addition, it is interesting to note that Borromini's patron from the time of his arrival in Rome was Cardinal Barberini, who was elected Pope Urban VIII in 1623. As Koestler points out in discussion of the acceptance of the new heliocentric astronomy, 'Galileo himself enjoyed the active support of a galaxy of Cardinals, including the future Urban VIII', who wrote a letter to Galileo expressing sincere admiration. As far as the new astronomy was concerned, Urban VIII showed a clear interest until the 1530s, by which time the fashion for elliptical domes in the Baroque had taken secure hold. Kepler forged both a mathematical methodology and interpretation of the universe that was likely to have appealed to Borromini on many levels. The most important would be Kepler's belief in the divine geometry ruling the structure of the universe and the manner of interpreting it.

Links between Borromini and Kepler

Borromini's elliptical domes also had a far more secure mathematical and geometrical foundation, possibly with a shared source with Kepler in Plato's *Timaeus* (54E–55C). Clearly, the ellipse had scarcely been considered as an architectural form before the seventeenth century and examples are very hard to find. Borromini, however, takes it as an overriding motif and the idea of the elliptical dome as a possible allusion to contemporary astronomical theory is reinforced by evidence of interest in astronomical symbolism appearing in much of Borromini's work (such as the Galleria Spada drawing for the chapel of the Collegio di Propaganda Fide, drawing for the Baldacchino of St Peter's Rome). Several other works by the artist also lend weight to the hypothesis. For example, evidence of interest in astronomical symbolism appears in his depiction of a sun symbol on his drawing for the Baldacchino at St Peter's in Rome. And in the drawings for the Oratory of S. Filippo Neri, S. Giovanni in Laterano and the Collegio di Propagande Fide he includes numerous star motifs and at S Ivo della Sapienza, Rome (1542), the six point starred decoration completely dominates – while the octagonal floor decoration within this hexagonal building also recalls Kepler's nested solids, especially in the solution of a border or dividing line, which also recalls Kepler's approach to polygonal forms. Borromini's letter to Cardinal Camillo Pamphili about the designs for his villa confirm his interest in mathematics and astronomy. Particularly significant is the startling inclusion of the motif of the icosahedron on the Filomarino altar in SS Apostoli, Naples (begun 1635), which seems to relate directly to Kepler's theory of the solids as expressed in his *Mysterium Cosmographica*, 1596. The curious inclusion of the two icosahedra on the top of the altarpiece have been pointed out as being related to Plato's *Timaeus* but no connection has yet been made with Kepler's theory of the solids.[4]

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[4] E. Baldwin Smith, *The Dome: A Study in the History of Ideas* (Princeton NJ: Princeton University Press, 1950); John G. Hatch, 'The Science Behind Francesco Borromini's Divine Geometry', *Nexus Network Journal* 4, no. 3 (2002); Thomas S. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought* (Cambridge: Harvard University Press, 1957); Karl Lehmann, 'The Dome of Heaven', *Art Bulletin* 28 (1945): pp. 1–27.

Conclusions
It is difficult conclusively to prove a direct connection between Keplerian theory and the Baroque architecture with elliptical domes, of Borromini and other architects of the period. In addition to extensive use of individual astronomical motifs, Borromini's major architectural schemes also appear to reflect scientific interests and recent developments. Additional examples can lend weight to the idea, such as the elliptical dome in the Italian Brothers Chapel in Prague – just a short walk from where Kepler lived during his stay there. Perhaps it is not coincidence that the dramatic introduction of elliptical domes occurs at about the same time as Kepler revolutionised the perception of the universe and its mechanics. The idea that the radical changes and transition to the use of elliptical domes in the Baroque period have a relationship to Kepler's elliptical orbits appears to merit further investigation.

By the seventeenth century, the influence of nature and its relation with mathematics were becoming ever more significant in art and architectural design. Borromini's dramatic designs are often based on manipulations of triangles, circles, ellipses and other geometrical figures, which may well relate to scientific writings of the age by Galileo, Kepler and others that were much studied in intellectual circles in Rome in the early seventeenth century.

Acknowledgements

Figure 1. S Carlo alle Quattre Fontane, Rome, 1634-41.

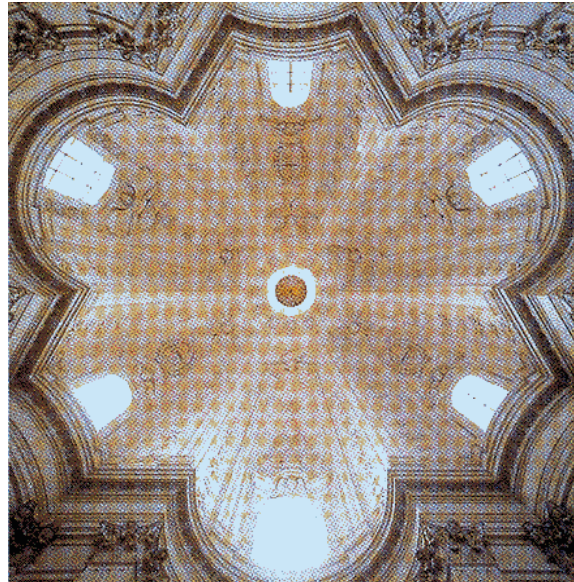Figure 2. S Carlo alle Quattre Fontane, detail.
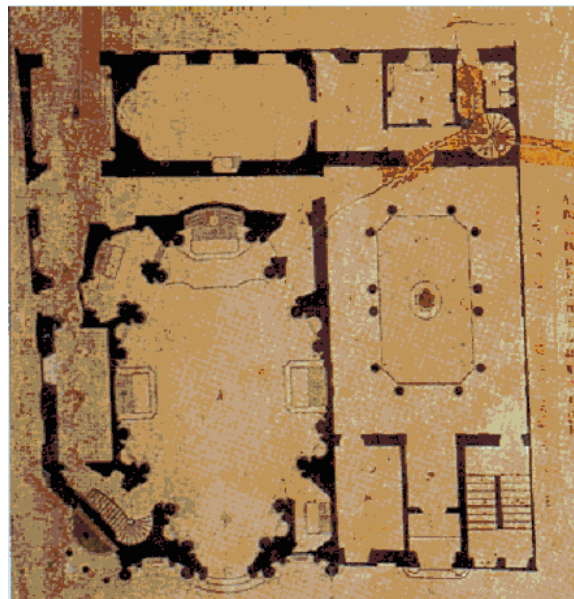
Figure 3. S Ivo, Rome, 1643-52.

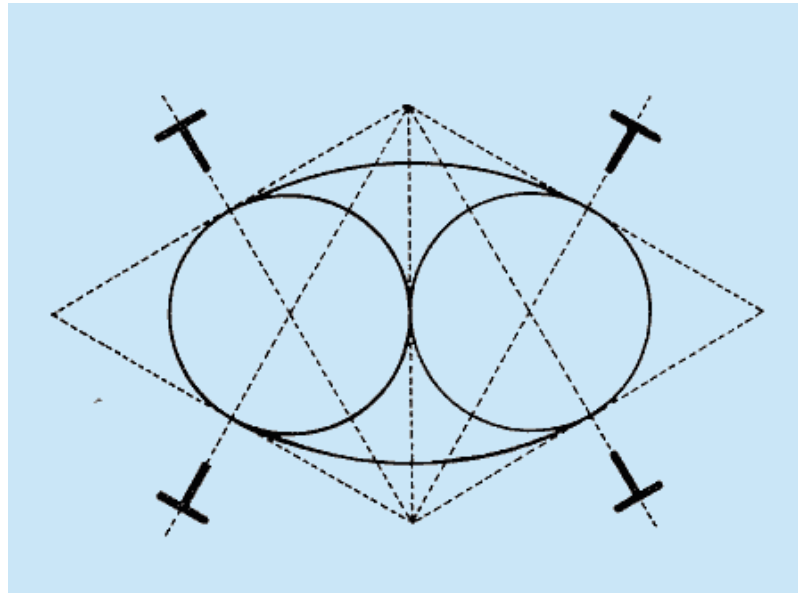Figure 4. S Carlo, architectural drawing, 1630s.

Figure 5. S Carlo, geometrical scheme.

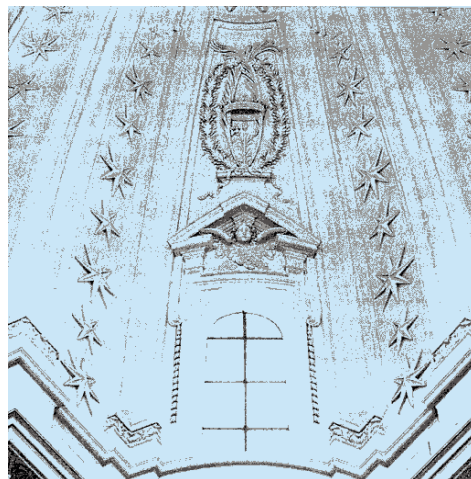Figure 6. Bernini, S Andrea al Quirinale, 1658-70.

Figure 7. S Carlo, façade, 1634-41.

Figure 8. S Ivo, detail of dome, 1643-52.