

# Chapter 49

## Architecture, Mathematics and Theology in Raphael's Paintings

David Speiser

### Introduction

The subject I am going to talk about belongs, one may say, to the prehistory of descriptive geometry: it is part of our modern discovery of space. Three times a civilisation has made such an investigation: in ancient Egypt, in Antiquity, and in modern times, where perhaps we should speak of space-time. And each time, not only science, but also the arts participated in this endeavour. It is always extremely interesting to compare the progress of the sciences with the evolution of the arts, as well as their histories, their results, and also their methods. But it is fair to say that in spite of many valiant pioneering efforts, so far this has not been done systematically enough: think for instance of medieval architecture and its importance for the progress of technology and science.

This small contribution is devoted to two mathematical, that is, geometric, discoveries made in 1503 and 1504, and presented in two famous paintings by Raphael: *Lo Sposalizio* (*The Wedding of the Virgin*) and *L'incoronazione della Madonna* (*The Incoronation of the Madonna*). It is especially in the second one that we find architecture, mathematics and theology closely intertwined in a way that is deeply characteristic for this artist, whom we can see here also as a great scientist.

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## La Dolce Prospettiva

Attempts to represent buildings in perspective go back at least to Giotto and his school. But it seems that around 1400 Masaccio was the first to discover the law of the vanishing point; I remind you here simply of the Christ on the cross in Sta. Maria Novella and of his Frescoes in Sta. Maria del Carmine.

North of the Alps, the early Flemish painters approached this law step by step, by trial and error. This process is described in an essay by Erwin Panofsky (1962); it seems that the first correct painting is Dirc Bouts' *Last Supper* in St. Peter's in Leuven. However, in all these paintings we find only the use of what is sometimes called, a bit misleadingly, "central perspective". This means that all buildings are presented to us frontally, and the horizontal edges are either orthogonal to our view, in the line of our view, or converging with it. Thus, there is always only one "vanishing point", the point towards which the parallels converge. A typical example is the *Giving of the Keys to St. Peter* by Perugino in the Sistine Chapel (Canuti 1931) (Fig. 49.1). Please note that this restriction forced the painter to place all buildings parallel to each other and frontally with respect to the observer: a severe restriction indeed! So we may ask: who was the first painter who succeeded in representing correctly a building in other than the frontal position?

Perugino's fresco dates from 1480/1481, and in a moment you will see a second, very similar one. But in 1503 his pupil, Raphael Sanzio, was invited to paint for the church of the Franciscans in Perugia an *Incoronation of the Madonna*, which is today in the Pinacoteca del Vaticano (Fig. 49.2). I think that this is the first painting where a structure in a non-frontal position, the sarcophagus of the Madonna, is constructed rigorously. At least I have never seen an earlier one myself. So the question arises: how did Raphael do it? How did he achieve what so many others, presumably, had tried to do in vain?

But first: can we be sure that the sarcophagus of the Madonna is constructed correctly? It is fairly easy to convince yourself that the long edges do indeed converge to a vanishing point. For the short edges, this is obviously a bit more difficult; I convinced myself that they do so, but it seemed that the vanishing point to the left lies a tiny bit higher. But this may be due to my clumsiness together with the fact that I had to work with a comparatively small reproduction, or it may be due to the fact that according to Jones and Penny (1983) the painting was transported from wood on linen.

So how did Raphael do it? You can see the answer in Fig. 49.3: draw the crossing of the extended shorter edge at right with the horizontal that passes through the summit at left, and then descend from the upper summit to this horizontal line and extend it beyond. Now you see that this extension covers two lines in the painting: one that lies in the horizontal plane, and a second one that descends vertically from the central crossing point through the centre of the right side of the sarcophagus! This means that the central crossing point is the centre of the two squares. In the next figure you can now see how Raphael proceeded (Fig. 49.4).

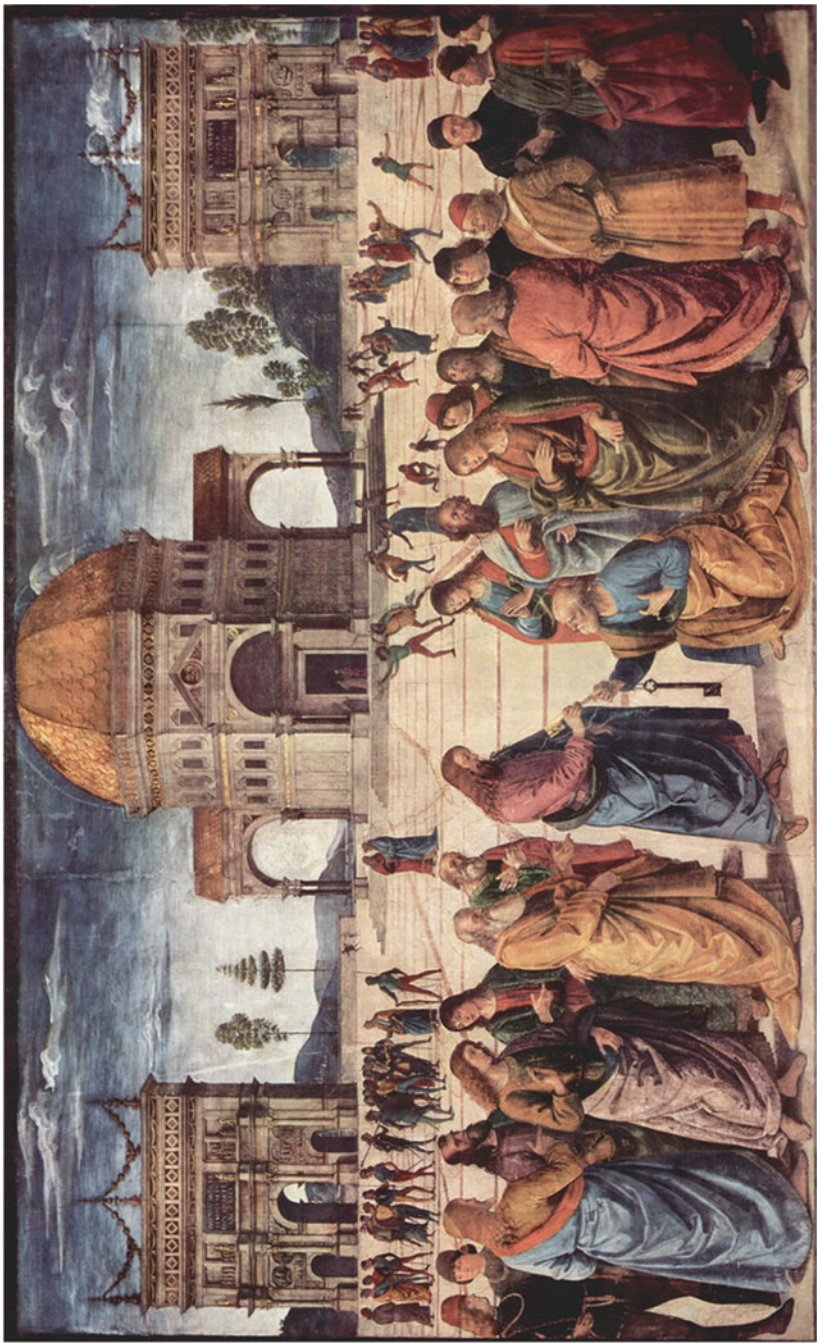
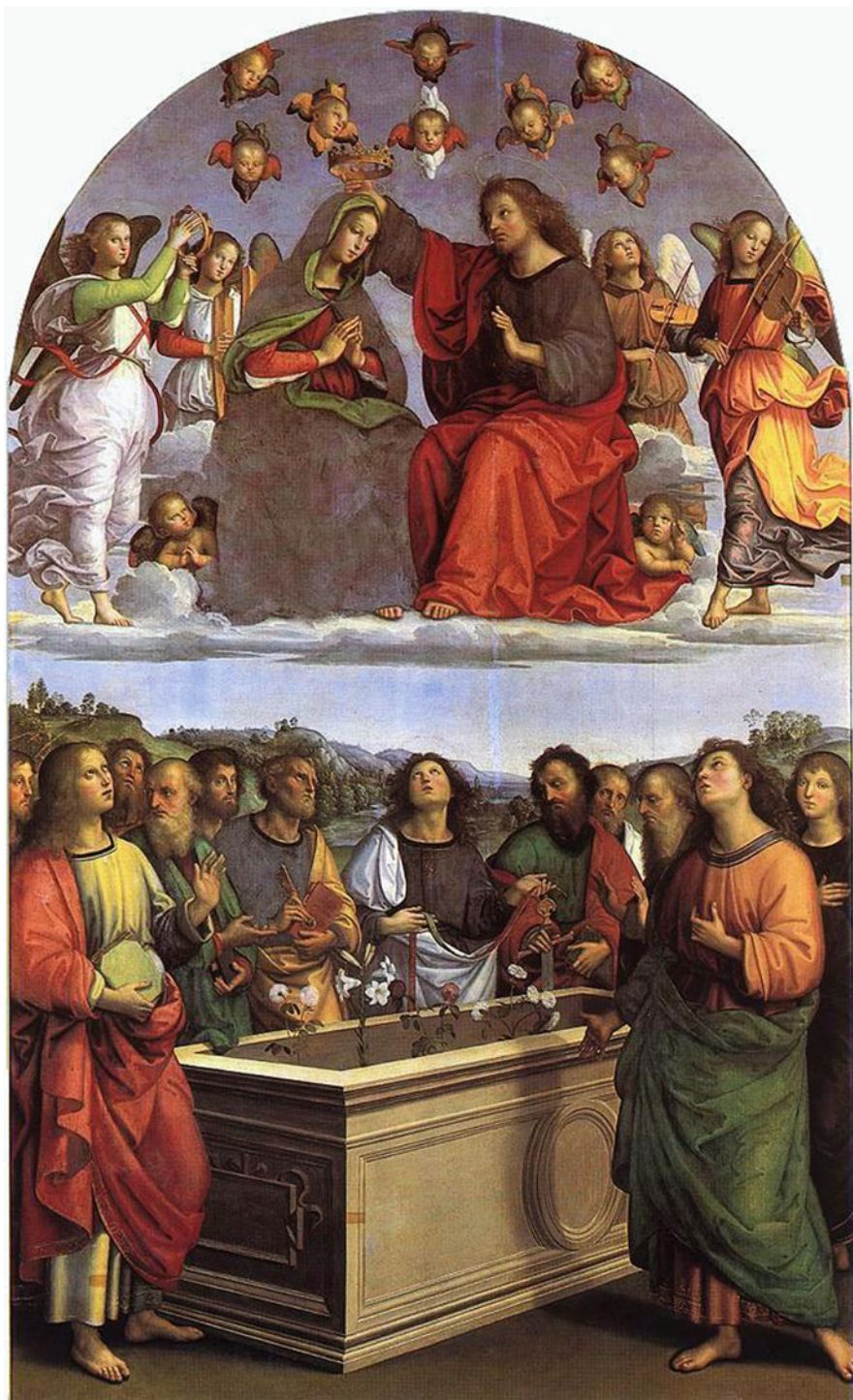


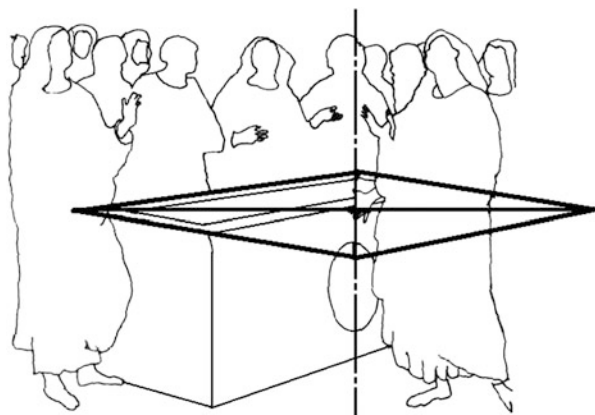
Fig. 49.1 Perugino, Christ giving the keys to Saint Peter, Sistine Chapel, Vatican City. Image: Reproduced by permission, Musei Vaticani



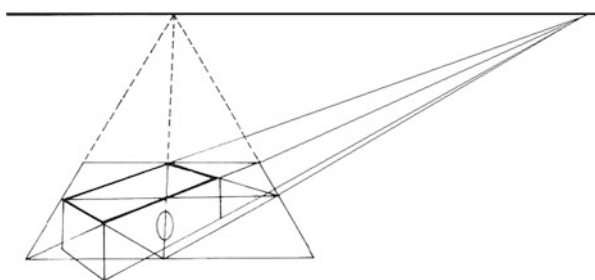


**Fig. 49.2** Raphael, *The Coronation of the Madonna* (Oddi Altarpiece), Pinacoteca Vaticana, Vatican City. Image: Reproduced by permission, Musei Vaticani

**Fig. 49.3** The perspective scheme of the sarcophagus, *The Incoronation of the Madonna*. Drawing: Kim Williams



**Fig. 49.4** Perspective construction of the sarcophagus. Drawing: Kim Williams



Raphael first drew a square, then he drew the diagonals that, finally, permitted him to draw the square whose corner points are the centres of the four sides. As often happens, it is all very simple, but one has to think about it! And this construction, while special indeed, is not only the very special case it might seem to be: namely a rectangle composed of two squares. You can, for example, extend the sidelines beyond the half-square and construct any rectangle with a line towards the vanishing point.

Having found the law of the two new vanishing points, Raphael has solved the problem of correctly constructing the right angle of any rectangle that is bisected by a line towards the central vanishing point. And my colleague M. Howald showed me a trick that allows one to draw correctly a building seen from an arbitrary angle. As he told me, it is contained in the writings of Leon Battista Alberti. That such a solution was looked for can be seen from paintings that try to give the impression of a building not placed frontally with respect to the spectator, although it is really placed this way. An example is Titian's famous *Madonna with Members of the Pesaro Family* in Venice: there this effect is achieved simply by placing the vanishing point far to the left, outside the painting. But buildings at which one looks obliquely remained rare for a long time. And in many of them a not-frontally-placed building is painted so that one cannot easily check its construction.

Now: theology. The painting makes indeed a theological statement, but one that is in accordance with the instruction of the Franciscans, who commissioned the painting: the Virgin is placed on the same level as the Christ, not lower, which is unusual. If Raphael himself made a theological statement here, it might be as I am about to explain, but I would not press the point. The axis of the geometric construction does not coincide with the axis of the painting itself. But the former concerns an earthly matter only, while the axis of the painting is determined by the heavenly order. Always remember, especially when we now go to *Lo Sposalizio*, that an altarpiece is a symbolic construction, and not only *un coin de la nature vu par un tempérament*! Indeed, at the time, some may have found Raphael's innovation too naturalistic.

## Lo Sposalizio

*Lo Sposalizio*, originally painted for Città di Castello, is now in the Brera in Milan (Fig. 49.5). The High Priest celebrates the wedding of the elected Joseph with Mary. Only Joseph's stick bursts into flower, and thus his companions break their own sticks, which remained barren. But what catches the eye more than everything else is the building designed by Raphael, its grace, its lightness and, indeed its elegance: one must look far ahead, deep into the eighteenth century to find such a graceful building. Many things contribute to it: the cupola; the colouring; the elegant arcs (the same that Michelangelo will use in an inverted position on the sarcophagi in the Medici Chapel). But if you look more closely, you see that the lightness is especially due to one accomplishment, with which the pupil beat his master, Perugino. Rather than the master's slightly heavy octagon, he constructed (and he was the first to accomplish this) a hexadecagon; the building has 16 sides! And this, as I shall now show, was no mean achievement.

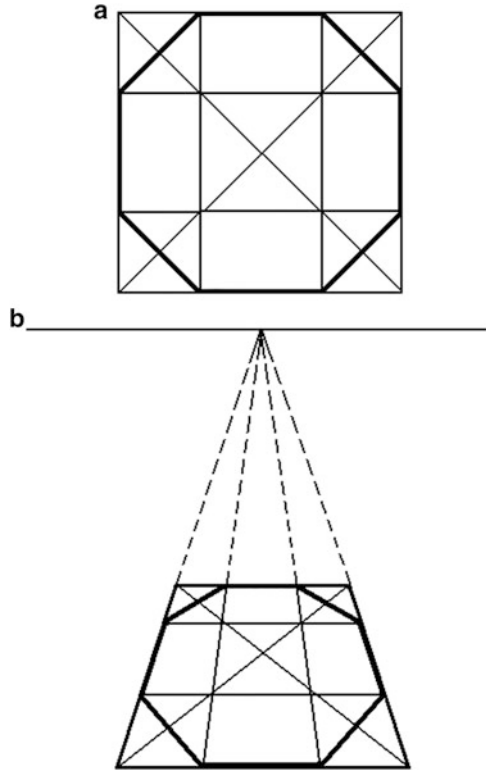
It is well known that a regular polygon whose order is a power of two can be constructed simply by bisecting a number of times successively an angle with a ruler. Starting from this result, the construction of such a polygon in central perspective must be obtained in two separate steps. Recall that on the horizontal line you can always assume Euclidean geometry to be valid, and thus I have indicated for the octagon the relevant lengths, which you can transfer directly onto the frontal line. But while this Euclidean construction is almost trivial for the octagon (Fig. 49.6a, b), for the hexadecagon it is more cumbersome: you must construct the equivalent of the extraction of a square root of a term which contains a square root (Fig. 49.7a, b). And then the perspective construction proper must follow; there are two ways to do it. You choose freely the angle from which you see the square (for example, you may choose the rear edge) and with either method you then draw the diagonals. The first way to construct the perspective is to extend the diagonals to the vanishing points found by Raphael, then draw the other, lower edges, then the lines to the central vanishing point, and finally the second horizontal, which yields the last two edges. Mathematically, this is the





**Fig. 49.5** Raphael, *Lo Sposalizio*. Pinacoteca di Brera, Milan. Image: Reproduced by permission, Ministero per i Beni e le Attività Culturali

**Fig. 49.6 (a, b)**  
 Perspective construction of  
 an octagon. Drawing: Kim  
 Williams



more transparent procedure, but you need to know the exact location of the new vanishing points, which, as was seen, are often way out of the painting. This difficulty can be avoided by drawing first the lines from all points marked on the frontal edge to the central vanishing point, and then directly the horizontals that yield the other edges. This method has the advantage that the painter need not work outside the painting. Which way Raphael actually used remains a guess. Indeed, both steps are fairly complicated for this figure, but Raphael worked rigorously: all parallels on any side of the hexadecagon meet at the same vanishing point; this is a grand accomplishment.

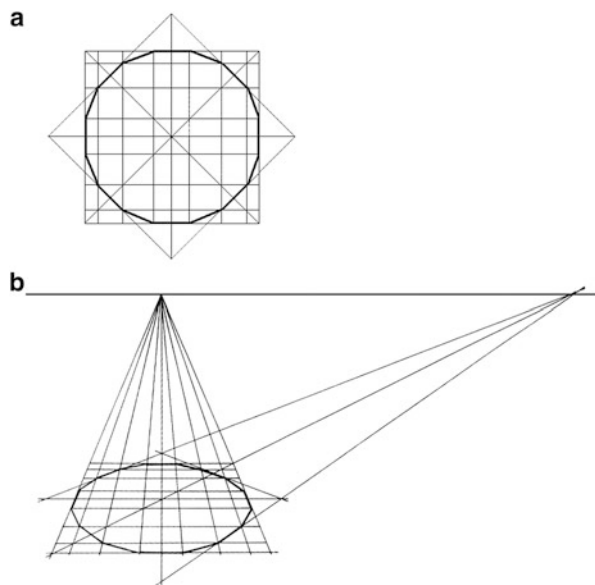
## Theology in Lo Sposalizio

The investigation of theological points made in works of art was introduced in this century by Aby Warburg and Erwin Panofsky under the broader concept “Iconology” (Panofsky 1962).

How does theology come into this painting? I will begin with what you may call the lowest level of it (Fig. 49.5). It is, I think, recognizable that the heads of the



**Fig. 49.7 (a, b)**  
 Perspective construction of  
 a hexadecagon. Drawing:  
 Kim Williams



Virgin's five bridesmaids form a regular pentagon, and those of the four companions behind Joseph a square. Of course, this may be due to nothing more than Raphael's well known desire to use geometric figures in his paintings for arranging the people in the painting, especially in depth, as well as to his unrivalled virtuosity of drawing in perspective. But he who draws (or, as here, forms) a pentagon, also draws a pentagram. Thus, where on so many churches, usually on the western front, we find a pentagram, even where it is artistically not especially wanted, there must be a special reason for it. As examples I mention Hannover, Strasbourg, Breisach, Basel and the largest cathedral in Italy at Raphael's time, the Duomo di Milano. No doubt, these pentagrams had a function: they served to keep out the devil, the *demonio*. Thus I suspect that the bridesmaids here are performing a pious service to the Virgin: they protect her, just as the four friends form a tower of strength for Joseph. But again, I will not press the point, and I pass right on to the higher level, that is, to the real theology, where we stay on safe ground.

Before doing so, I must say a word about the western tradition of the representation of the temple. There are two aspects to this tradition: one aspect follows the Biblical descriptions of Solomon's Temple, and Ezekiel's vision. The other aspect, which Raphael follows, goes back mainly to the crusaders and is based on what they saw, namely the octagonal mosque by Abd al-Malik, which they imagined to have been built in the tradition of Solomon's Temple: the seat of Wisdom. As such, it became a symbol, not only of the church and of wisdom itself, but also of Mary, the seat of true Wisdom. Still today in Louvain-la-Neuve the academic year is inaugurated, *Au nom de Notre Dame Siège de la Sagesse*. This tradition found expression also in numerous altar chapels, tabernacles etc., which

always stand for the Temple, the Wisdom and the Virgin in one, as you can see in the interesting book by P. von Naredi-Rainer (1994).

But while the real Temple in Jerusalem was directed towards the East, since Yahweh enters into his house from the East, Raphael orients the front towards the West, as you can see from the shadows cast by the figures; thus the spectator looks towards the East.

I come now to the second step which Raphael took beyond his master, who also painted a picture with an octagonal temple, but the subject of which is a *Sposalizio* (Fig. 49.8), now in Caen. Both paintings were finished in the same year, and there is no doubt that the master had begun his considerably larger painting much before. Thus priority in choosing the subject belongs to him, as well as the idea of arranging the couple and the high priest frontally before the temple. In both paintings, contrary to Perugino's fresco in the Sistine Chapel, the door of the Temple is open, and there, in the opening, lies the vanishing point, so that you can follow the lines of view in the painting towards it. Is this innovation with respect to Perugino's first fresco due to the master or to the disciple? I do not know, and the question seems to be a difficult one to decide. In any case it was Raphael who saw the artistic possibilities that this seemingly small step permitted (Fig. 49.5). Perugino's painting is arranged in two frontally oriented layers: the group of the people, more or less on one line before the Temple, and the Temple itself, which serves mainly as a historical indicator for the narration.

Raphael's painting shows, as the German historian Hiller von Gaertringen (1999) says, *Tiefensog*, that is, a pull towards the pictorial depth. Besides breaking the one line of people up into geometrically composed groups, he accomplishes this by constructing these many squares, forcing the spectator to follow their edges with his eyes. And these edges meet where? Why, at infinity! And who has his seat at the infinitely distant? Of course: HE, God! Looking towards the vanishing point, you look towards infinity: you look towards God.

It is worthwhile to pause here. We often say that parallels meet at infinity, but this is not so according to Euclidean geometry. The figures can extend to the infinite, but Euclidean geometry makes only asymptotical statements about it, and this holds even more for mechanics, which it underlies and upon which its constructions depend. Bodies can go to and come from the infinite but we compute their behaviour in finite parts of space and only asymptotically with respect to the infinite.

It is different in projective geometry. There parallels do meet at infinity, and projective geometry underlies the perspective design and the corresponding theories of our view. Today we can formulate conceptually the difference between the two geometries; at that time this was not possible, there was only an idea, and it is natural that an artist could grasp it before and better than anyone else. This is why Raphael underlined with all means at his disposal this convergence towards the vanishing point in the open door: everything leads you to the infinite. Projective geometry and perspective serve here as a symbolic construction!

This is Raphael's first theological statement, and it is expressed through the mathematics of perspective. I doubt that any theologian could have expressed this



**Fig. 49.8** Perugino, *Lo Sposalizio*. Image: Reproduced by permission, Musée des Beaux-Arts de Caen. photo: M. Seyve

idea; what was needed here was a mathematician, since mathematics is the very science of the infinite! But this statement was in line with the Florentine Platonism of the time, one of the roots of which was the “Docta Ignorantia” of the German philosopher and Cardinal, Nicolaus Cusanus.

That I am not imagining these things is attested by Raphael's second theological statement, and this time it is the architect who makes it by designing this magnificent edifice. Namely, you look towards God, if you look towards him through the church.

Altarpieces of this time are loaded with theological implications, but most often clad only in traditional, historic and sometimes accidental symbols. A construction like the one we find here, where architecture, mathematics and theology are so closely knit and intertwined, is surely extremely rare, if indeed not unique. For producing it, an architect, mathematician and theologian in one person was needed.

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In the 1950s, as a student I could discuss regularly the secrets of the use of perspective by the artists with my friend L. Burckhardt, and later, in the 1960s, I had the chance to have conversations on these questions with Erwin Panofsky. I could discuss these questions with Dr. Mario Howald, Dr. and Mrs. Th. Beck helped me with the literature and Mrs. M. Messmer pulled me out of laptop difficulties. I am greatly indebted to Kim Williams for translating my English and for drawing the figures! Last but not least I am indebted to my wife for linguistic advice and for proof reading.

**Biography** David Speiser is Professor Emeritus at the Catholic University of Louvain, where he taught physics and mathematics from 1963 to 1990. His research concerned elementary particles and physical mathematics. From 1990 to 2004, he gave lectures and seminars regularly at the Scuola Normale di Pisa. He was the general editor of the complete works of the mathematicians and physicists of the Bernoulli family from 1980 to 2004. His essays on the relationships between the history of art and the history of science have been collected in *Crossroads: History of Science, History of Art. Essays by David Speiser, Vol. II*, Kim Williams, ed. (Basel: Birkhäuser, 2011).

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