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The Geometries of Robert Grosseteste and the Architecture of Lincoln Cathedral

John Hendrix

(**Nave**) I would like to demonstrate the relationship between the geometries used by Robert Grosseteste, Bishop of Lincoln from 1235 to 1253, in his cosmologies, and the geometries used in the architecture of Lincoln Cathedral between 1190 and 1253. This is not to suggest that the architecture was dictated by the Bishop, but the geometries were similar enough to suggest that a cultural concept of a geometrical substructure of matter could be translated into the architectural forms of the cathedrals as catechisms of the structure of matter and being. The architecture of the cathedrals was intended to edify the viewer as to the underlying nature of being and as to the relation between the human intellect and nature and God. The cosmologies of Grosseteste which contain geometries which can be found in the architecture include *De lineis, angulis et figuris*; *De natura locorum*; *De iride*; and *De impressionibus elementorum*. These treatises are considered to be the progenitors of natural or scientific philosophy. Geometries used by Grosseteste to describe the diffusion and rarefaction of light in the formation of matter can be compared to the peculiar geometries of the vaulting of Lincoln Cathedral, in the particular lines and line segments of the vaulting. Volumes formed by the reflection and refraction of light, as described by Grosseteste, can be compared to the volumes of the vaulting, in particular the concave and conical shapes. The *lux*, or spiritual light, and the *lumen*, or physical light, can be applied to the light in the cathedral, as shining through the stained glass windows and illuminating the geometries. The stained glass windows in the Great Transept of Lincoln Cathedral, the Dean's Eye and Bishop's Eye, can be seen as the *oculus mentis* of the cathedral, directing the *visus interior* of the *anima rationalis* to the *lux spiritualis*, illuminating the mind and bringing the *virtus cogitativa* or *nous hylikos* closer to

the *virtus intellectiva* or *nous poietikos*, or bringing the mind closer to *intelligentia*, divine intellect.

The most important treatise of Grosseteste which contains explanations of geometries which can be found in the architecture of Lincoln Cathedral is the *De lineis, angulis et figuris*, translated as *On Lines, Angles and Figures, or the Refraction and Reflection of Rays*. The treatise was written at Oxford, within two years of Grosseteste's appointment as Bishop of Lincoln. The primary role that geometry plays in this particular treatise is the most important key to formulating an interpretation and understanding of the generation of architectural forms in the cathedral, based in the geometries, as they are related to philosophical concepts. Such an analysis can perhaps provide an important level of understanding of the forms of English Gothic architecture, as they are introduced at Lincoln. Grosseteste begins the treatise by stating that lines, angles and figures are essential for a knowledge of natural philosophy, based on the *Posterior Analytics* of Aristotle. According to Grosseteste, geometry is applicable to phenomena throughout the universe, in motions, both straight and circular, causes, effects, the actions of material things, and the operations of the senses in relation to material things, in particular visual perception.

In the *Commentary on the Posterior Analytics* of Grosseteste, written around 1230, there are two kinds of *species*, or forms, which correspond to the two kinds of light as defined by Grosseteste. *Species apprehensibilis* is the *species* or *similitudo* which does not participate in matter, and is entirely separate from matter as an intelligible, like *lux*, the incorporeal, spiritual light. *Species sensibilis* is the *species* that participates in matter, that is connected to the material form or object in nature, but at the same time it is independent of it. The *species sensibilis* corresponds to the *lumen*, the light which participates in matter as a reflected and refracted, rarefacted and diversified form of the incorporeal *lux*, while at the same time the *lumen* is independent of matter, and is a manifestation of the *lux*. It is the *species sensibilis* which participates in the steady operation of diversification, directing that which occurs in perception, and forming the basis of reason, while perception and reason themselves are formed of the *species apprehensibilis*. The *species apprehensibilis* creates a *virtus* or *similitudo* in understanding.

In the *De Lineis* of Grosseteste, the *virtus* from the natural agent is

more active and more unified if it is along a shorter line, because it is closer to the recipient, the passive agent, and it is less active along a longer line, because of the greater distance from the recipient. A light is brighter if it is closer to the eye, for example. Shorter lines contain a more condensed *virtus*; in architecture they are more structurally sound, and exert greater force on an adjoining member. (**Nave vault**) In the vaulting at Lincoln Cathedral, the ribs are divided into the long longitudinal ridge pole, the transverse ribs which cross the vault, the tierceron ribs which connect the ridge pole to the springer but do not provide structural support for the vault, and the lierne ribs, the shortest of the ribs which connect the transverse or tierceron ribs, do not reach the springers of the vault on the sides, and provide no structural support.

The hierarchy of ribs in the vault corresponds to the hierarchy of lines described by Grosseteste, with different degrees of *virtus*, and different concentrations of *species*. The *virtus* proceeds immediately from the natural agent along either a straight line or a bent line. The action of the *virtus* is greater along a straight line, as was established by Aristotle in Book V of the *Physics*, where a straight line is the shortest path between two points, and in Book V of the *Metaphysics*, where the straight line is more unified than the bent line. The straight and bent lines, the latter formed by the lierne ribs, are also present in the vaulting of the cathedral, and in the tracery of the stained glass windows.

In *De Lineis*, the *virtus* is weaker along the reflected or incident line, as, for example, light is weaker when it is reflected. Light is strongest in reflection when it is reflected from smooth surfaces like mirrors, and weakest when it is reflected from rough surfaces, as then the *species* is more dissipated, less concentrated. The *virtus* is greater in a reflection of light from a concave surface, because then the rays of light converge at a point, forming a cone of light. Lines emanating from a concave surface and converging at a point, in the form of a cone, can be seen in the vaulting at Lincoln Cathedral: the ribs of the vault begin at the ridge pole and converge at the top of the springer shaft, forming a convex surface in a cone which is formed by the severies between the ribs, or the surface of the vault which the ribs define. The corbel at the top of the springer shaft can be seen as a point of convergence, a nodal point, at which the *virtus* is greatest and the *spe-*

cies the most concentrated, as it is intended in the architecture, as the corbel is the most important visual point in the divisions of the bays longitudinally in elevation and vaulting, and the most important visual point in connecting the vaulting to the elevations.

The corbel is the point at which the vault springs from its supporting structure, but it is clear when looking at the architecture that the corbel and the springer shaft below it do not actually support the ribs forming the vault, or the vault itself. The springer shaft just runs down the wall to the spandrels between the arches, and stops at another corbel. Any relation that the forms of the architecture have to the structure of the architecture is entirely visual, it is pure *species*, a *species apprehensibilis*, and the structural logic of the vault depends on vision alone, so there is a necessity of concentrating the *virtus* at the point at the end of the cone, where the lines converge from a surface, which is the corbel at the bottom of the ribs. The structural logic which is understood in the cathedral is in the geometrical relationships enacted based on the principles of natural philosophy as described by Grosseteste in *De Lineis*, and not by the actual structure of the building, which is inaccessible to the visual experience of the architecture.

The mathematical structure of the universe is realized as the geometrical structure of the universe, thus as a corporeal body, in the same way that the tetractys was transformed by Plato into the progression from point to line to surface to body. According to Grosseteste in *De Luce*, his treatise on light, bodies are composed of surfaces, and surfaces of lines, and lines of points, referring to Aristotle in *De Caelo et Mundo*, and Plato in the *Timaeus*. The process of transference from numerical ratios to geometrical figures to material reality, the process of creation, can be found in the writings of Grosseteste, and in the architecture of Lincoln Cathedral. The process is present in Grosseteste's model of light and vision, where the origin of light is a point, the *virtus* of the light travels along a line, the lines of light emanate to the surface of the circumference of a sphere, and the emanation of the light forms the volume of a cone. Conversely, the lines of light converge at the apex of the cone in the eye of the viewer, the point which is also the origin of the extramission of rays of light, which also form lines and define the surface of an agent, forming the *species* which defines the corporeal volume or body.

In the architecture of the cathedral, the architect begins with points from which he constructs lines, from which he constructs a geometric surface, from which is projected or telescoped a three-dimensional structure. This can be seen for example in the vault of the nave, where the point of the corbel at the top of the springer shaft in elevation is the source of the lines of the ribs of the vault, which form a convex surface in combination with the severies or surfaces of the vault, which forms a cone in the direction of the ridge rib of the vault, which can be seen as defining the surface of the agent. The cone of ribs as a cone of lines of light is reflected on the other side of the ridge rib.

(**Chapter House**) The cone of the lines of light can also be seen in the umbrella vault in the chapter house of the cathedral, which converge at a point on the top of the shaft in the center, and which spread to the ribbed vault as the surface of the agent. In *De Lineis*, the refracted line of light has more *virtus* than the reflected line of light, as it was established that the refracted line has more than one *virtus*. The opposite direction which the reflected line takes weakens its *virtus*. The more perpendicular the refracted line is to the line of incidence, the stronger its *virtus*. A fourth kind of line, along with the incidental, refracted and reflected, is the accidental line, which projects a *virtus* which does not come immediately from the agent, but from the three other kinds of lines. The light of the accidental line would be the *lumen*, the secondary, reflected, corporeal light, in relation to the *lux*, the originary light. Accidental light passes from a ray descending through a window to all corners of a house, as described by Grosseteste. It is the light which is diffused through space, in lines of very little *virtus*, the weakest of all, because it originates from a refracted line, and passes along a secondary reflected or refracted line.

(**Transept**) In the cathedral, for example the northeast transept, the accidental light is the light which fills the space after rays of light have come through the windows. It is a secondary light and not a spiritual light, as it does not emanate directly from the *lux*. The spiritual light is the light which passes directly through the windows, in the incidental, reflected and refracted lines, as they interact with the colors of the glass and the patterns of the tracery in the stained glass. The *lux* is the intermediary between the spiritual and the material, between soul and body, between the infinitely simple and the geometrical. The patterns of the tracery, at Lincoln the Y-tracery or intersecting arch tracery in

the stained glass windows, reiterate the actions and geometries of the spiritual rays of light, and transform the *species sensibilis* formed by the light into the *species apprehensibilis*, the geometries and mathematical relations which form the intelligibles of the structure of the cathedral and the natural world, which are accessible to intellect through sensible perception, of the light and geometries, and which allow the observer in the cathedral to communicate with the divine origin of the physical world, to bridge the gap between reason and faith, through the intelligibles in intellect as they are represented in the *species* of the light and geometry. Such a communication requires the activity of *nous*, the higher form of intellect, that part of intellect which is unknown to itself, but which is made known for Grosseteste through the sensible experience of the perception of the *species* in relation to the intelligibles.

Light represents the presence of what is not material, and for that reason light played a core role in the design of the Gothic cathedral from the beginning, when the Abbot Suger was inspired by the writings of Pseudo-Dionysus at the Abbey Church of St. Denis north of Paris at the beginning of the twelfth century. Grosseteste's treatises, *De Lineis* and *De Luce*, are important elaborations of the light metaphysics which played such a core role in the architecture. Beginning at St. Denis, the objective was to allow as much light as possible into the cathedral, to eliminate the heavy, opaque walls of the Romanesque cathedral. Light was allowed through the cathedral by the rarefaction of the structural materials: the piers became thinner and the arched openings became larger, allowing for an increased transparency and more complex visual experience in the cathedral, which corresponds to the light theory of Grosseteste, in the rarefaction and multiplication of light, and to Grosseteste's theory of vision, in the relation between the eye of the perceiver and the light from the object perceived.

As in the Scholastic treatise, the different parts of the cathedral are designed to stage a series of visual relationships based on connections created by the variations in theme, as all matter is connected while it is being rarefied by light, as Grosseteste describes in *De Luce*. This is what Erwin Panofsky calls the principle of progressive divisibility, and it can be seen in the vaults, triforia, piers, shafts, window tracery, arcades and mouldings of the architecture. Every detail of the geometry of the cathedral participates in the same logical system, to express the

idea that the natural world can be understood by reason, in mathematics and geometry, as in *De Lineis* and *De Luce*, and that scientific philosophy can by synthesized with religious faith, at the very beginning, in the figure of Grosseteste, of the Great Synthesis.

(**Bishop's Eye**) The articulated details of the architecture, as the *manifestatio* of the principle of progressive divisibility, are the product of the diffusion and rarefaction of light into the physical world, as it transforms from *lux*, the spiritual light, to *lumen*, the corporeal light. The rose windows at Lincoln, for example the Bishop's Eye in the southwest transept, and the multiplicity of the forms bound together in a single comprehensive system, stage the Scholastic understanding of the operations of the cosmos. The all-encompassing interrelationships of all the membrification of the Gothic cathedral constitute what Panofsky calls a postulate of mutual inferability, creating a variety of visual transitions and interpenetrations, spatial juxtapositions and overlappings, which correspond to the multiplication, diversification, and rarefaction of matter in light, as described in *De Luce*.

In *De Luce*, as light extends matter in all directions equally into the form of a sphere through infinite multiplication, the further out the parts of matter are, the closer to the surface of the sphere, the more extended and rarefied they are. There is a hierarchy of rarefaction in matter, as there is a hierarchy of rarefaction in the architectural forms in the cathedral. (**Dean's Eye**) This can be seen in particular in the vaulting systems and the tracery in the stained glass, for example the Dean's Eye in the northwest transept, where the density at the center gives way to thinner and less dense membrification toward the outer edges. In the vaulting, the density of the cluster of ribs at the corbel gives way to more spread out membrification toward the ridge pole at the center of the vault. In each case the membrification can be seen to be rarefied toward a circumference, as matter is rarefied toward the sphere of the cosmos by the autodiffusion of *lux*.

After finishing his discussion of lines and angles in the *De Lineis*, Grosseteste turns to a discussion of figures. There are two essential three-dimensional geometries; the first is the sphere, because *virtus* is projected from every agent spherically. *Virtus* is necessarily projected spherically because it is projected everywhere, and the sphere is the geometry which encompasses all of space. The *virtus* is projected from the agent as *lumen*, corporeal light, from the *lux* of the spirit, the first

corporeal light which is also incorporeal, in a process of autodiffusion, as described in Grosseteste's treatise on light, *De Luce*. The means of the translation of the *lux* to the *lumen* is the *species*, as described in *De Luce*. For Grosseteste, this requires the activity of the *species*, and the projection of the *virtus* in all directions, thus to the form of the sphere, and from all directions, thus to the sense organ.

The second figure in *De Lineis* required for a natural action is the pyramid or cone. The apex of the cone is the point of the receiver at which the *species* of the *virtus* is received, as condensed from the agent, such as the corbel in the elevation of the architecture, in the catechism of light and vision, or the eye of the perceiver in vision. The point in the eye of the perceiver is the source of the extramission of light, which also forms a cone with the lines of the rays of light entering the sensible world. The first, dimensionless point is pure light, the *lux spiritualis*. The *virtus* is full and the effect is complete, and the passive object can be affected in passive vision, only when all lines converge on one point, the eye of the perceiver.

In the *Commentary on the Posterior Analytics*, the *lux spiritualis* floods over intelligible objects like the light through the stained glass window in the cathedral, and over the mind's eye, and stands to the interior eye and to intelligible objects as the corporeal sun stands to the bodily eye and to visible corporeal objects, as described by Grosseteste. The *lumen spiritualis*, the light produced by the *lux spiritualis*, allows the mental sight, the *visus mentalis*, to apprehend the intelligibles in the *virtus intellectiva*, as the light of the sun, the *lumen solare*, makes vision possible. The *lumen spiritualis* is the first visible in interior sight, *visus interior*, as the colored body is the first thing receptive of the light of the sun. The colored glass in the stained glass window corresponds to the *lumen spiritualis* in the *oculus mentis*.

The more receptive the intelligible object, the *species apprehensibilis*, is to the *lux spiritualis*, the more visible it is to the *oculus mentis*. The object which is most similar to the light, the least material, is the most receptive of it. The power of the mind, the *acies mentis*, is a spiritual light, an *irradiatio spiritualis*, which operates in the *virtus intellectiva* to illuminate the *species apprehensibilis*, and the *virtus* is strongest when the object is the least material and conforms most easily to the immaterial *species*. The architecture of the cathedral presents a hierarchy of materiality in forms, like the hierarchy of the celestial

spheres, following the principle of divisibility, in the multiplication and division of the architectural forms, culminating in the pure *lux spiritualis* which enters through the stained glass window.

Each of the stained glass windows at Lincoln, in particular the Dean's Eye and the Bishop's Eye, is the *oculus mentis* of the body of the cathedral. The colored glass is the *lumen spiritualis*, and the geometry of the tracery is the *species apprehensibilis*, the intelligibles of the architecture, and the structure of the cosmos, visible to the *oculus mentis*. The sight of the mind, the *visus interior*, is turned toward darkness and idleness when deflected from the *lumen spiritualis*, and is occupied with corruptible bodily things, but when it perceives a trace or *vestigium* of the *lux spiritualis*, it seeks it out, as the visitor to the cathedral seeks out the stained glass window, and then the *visus interior* is able to perceive the *lumen spiritualis* within.

(**Choir vault**) The analogy of spiritual light to corporeal light was applied by Grosseteste to elements of the operations of the Church. In *De Libero Arbitrio*, or *On Free Will*, the analogy is applied to the Trinity, as the *lux spiritualis* is the mediation between the intelligible and material in the same way that the Holy Spirit is the mediation between the Celestial Father and the Body of Christ. In the architecture of Lincoln Cathedral, the Trinity is present especially in Saint Hugh's Choir, in the grouping of three lancet windows per clerestory bay, and in the triradial vaults in the ceiling, where three ribs emanate from each boss along the ridge pole, causing the asymmetrical syncopation. In the choir the *lux spiritualis* shines through the triune lancet windows and mediates between the spiritual and physical, as in the Trinity, and shines the *species apprehensibilis*, represented by the forms of the glass windows, onto the *oculus mentis*, the mind's eye of the observer, in the form of the *species sensibilis*, represented by the triradial ribs in the vaulting, as they take the form of corporeal geometry. The transition from the windows in the clerestory to the vaulting of the ceiling represents the transition from the *species apprehensibilis* to the *species sensibilis*; it represents the formation of matter through light, where matter becomes denser and more substantial as the lines of the rays of light become more multiple and the *virtus* becomes stronger, in the process of condensation and rarefaction; and it represents the formation of the material world from the point to line to surface in the two-dimensional pattern of the lancet windows, and the line to surface

to solid in the vaulting pattern, concave surface, and volume of the vault.

(**Arcade**) It is conceivable that artists and builders in early thirteenth-century England applied models in optics and perception to artistic production, though there is no documentation of such an application. Folke Nordström, in an article in *Art Bulletin*, suggested that there is a relation between the vaulting of Saint Hugh's Choir in Lincoln Cathedral and the optical theories of Robert Grosseteste in his natural philosophy, as in the *De Lineis*. Along with the geometries of the architecture, the conoid springer vaults and umbrella vault, and the lierne and tirceron ribs, there is also the role of mirror reflections and anamorphosis in the effect of the architecture, in the asymmetrical vaulting of the choir, and the syncopated overlapping arcading of the choir, which would lend to that explanation, along with the overlapping and framing of vistas in other elements of the architecture.

The architecture is an *edificium* of the processes of creation and perception as described by Grosseteste, and it is an instrument for the intellection of the observer; the perception of the catechism of the architecture inspires the viewer to engage the *virtus intellectiva*, to understand the relation between reason and intellection, the material world and the spiritual world, and the body and the soul. The models of light and vision of Grosseteste, and the architectural forms of the corbels, ribs, severies, and vaults in Lincoln Cathedral, in their enactment of the role of the point and line, surface and solid, are allegorical models, catechisms or cosmologies, of the transformation of archetypal forms in the intellect to sensible forms in the material world.