Through the Layers of Time – The Evolution of Interlaced Ribbed Domes from Islamic Spain to the Italian Baroque

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Introduction

The Mediterranean Sea, the cradle of western civilization, witnessed countless cultural interactions in its wine dark waters. Egyptian, Greek, and Roman civilizations are the main players in this historical drama, with Islamic civilization joining in 700 CE with its spread to the Iberian Peninsula. The Architectural heritage registers traces of this past in the interlaced ribbed domes found throughout the area. The typology is composed of intersecting arches transforming the mass of traditional domes into lattice structures. Interlaced ribbed domes appeared first in Andalusia, known at the time as the kingdom of al-Andalus. Outside the Iberian Peninsula the typology registers a limited spread reappearing in the works of Guarino Guarini almost one thousand years after its first introduction. A priest and mathematician from the seventeenth century, Guarini designed several iterations of interlaced ribbed domes, adapting its compositional and structural principles to Baroque sensibility. Most of these designs were never realized and survive in the present day in graphic form only. Guarini never mentioned the Islamic origin of the typology indicating instead Gothic architecture as precedent inspiring these compositions. Indeed, the Spanish chapter of Gothic architecture retains several influences rooted in Islamic principles. Starting in the sixteenth century, France and Spain would refine their construction techniques giving birth to Stereotomy (the art of stone cutting) by looking at Gothic architecture for inspiration. However, where France applies Gothic principles to compositions in line with Roman architecture, Spain embraces Gothic aesthetics building Stereotomy upon its own cultural heritage.

Therefore, the presence of Islamic themes in Guarini's architecture should not come as a surprise. The visual similarities between Guarini's dome for the Church of San Lorenzo (Turin, 1668-1687) and the vaults in Cordoba's mosque (711 CE) highlight a temporal link overriding cultural and religious differences while celebrating the artistic achievements of the human mind on a global level.

Genesis and evolution of interlaced ribbed domes in Spain and Italy

The first appearance of interlaced ribbed domes on the European stage can be traced back to the Islamic kingdom of *al-Andalus*. This satellite centre of Islamic civilization established its main city in Cordoba [1], whose foundation predated the arrival of the Muslims in 711 CE [2]. When the Umayyad Dynasty reached the city, Cordoba already had experienced a mingling between its Roman foundation and the traces of the following Visigoth domination. The arrival of a new civilization celebrated these traditions, promoting a peaceful coexistence. The roots for this cultural freedom were settled in a schism with the MiddleEastern homeland. Al-Andalus reclaimed its independence when its founding Umayyad Dynasty was replaced in the homeland by the Abbasid caliphate [3]. The new established culture embraced previous traditions and religious beliefs. In fact, the first congregational mosque in Cordoba was hosted in the original Visigoth cathedral of Saint Vincent – a building shared with the local Christian population [4]. With the building passing entirely into Muslim hands in 785 [5], the original cathedral was replaced by a new Islamic sanctuary [6] whose features combined Roman elements such as double-tiered arcades (which scholars link to the Roman aqueducts in Merida) [7]. The use of double-tiered arcades was not a novelty for mosques, having already appeared in the Great Mosque in Damascus [8] and in the Dome of the Rock in Jerusalem [9]. However, in these precedents the peripheral walls established a strong sense

of enclosure which in Cordoba is virtually erased by a countless repetition of vertical supports. The arcades themselves are also open to re-interpretation. Their composition uses a chromatic alternation of bricks and stone while the arches are arranged in two tiers with different layouts: a semicircular profile in the upper tiers and a horseshoe setting in the lower ones [10]. These two features may constitute a visual device aimed to direct an observer's attention away from the irregular columns in the mosque. The vertical supports were acquired from various Roman ruins in the area, therefore displaying variable proportions. The re-use of architectural elements was a common practice which, in the specific case of Cordoba, may reflect the cultural mingling on site [11]. The disadvantage, however, was a necessity to introduce several bases and *pulvini* [12] to fit these elements into the existing composition.

Cordoba's mosque received several alterations and additions through time. Among them, the most relevant intervention for this research appears in 916 under *al-Hakam II* when a *maqsura* [13] was added to the building. A *maqsura* is composed of screen walls (usually in wood or metal) separating its occupants from other worshippers [14]. The typology is generally associated with Umayyad palaces, where it precedes the throne room [15]. Compositionally, a *maqsura* towers the rest of the building by raised gables (on the outside) and domes (in the inside) [16]. The inclusion of such as typology into a mosque is unusual but not unprecedented (the Great Mosque in Damascus had a *maqsura*). Here the complex separates the devotional space from the *mirhab* (which indicates the direction of the Kaaba in Mecca) [17]. In Cordoba the typology acquires a dynastic meaning – a celebration of the Umayyad resilience [18]. In line with the innovations in the mosque, the *maqsura* transforms – its carved screens disappear, leaving space to five-foiled interlaced arches overlapping to the double-tier arcades repeated in the building [19]. This new layer aims to strengthen the overall peripheral structure of the *maqsura*, counterbalancing the thrusts of its domes [20]. Composed of three bays, the *maqsura* presents two typologies of interlaced ribbed domes [21]: one type in its central bay and a second one for the two side bays.

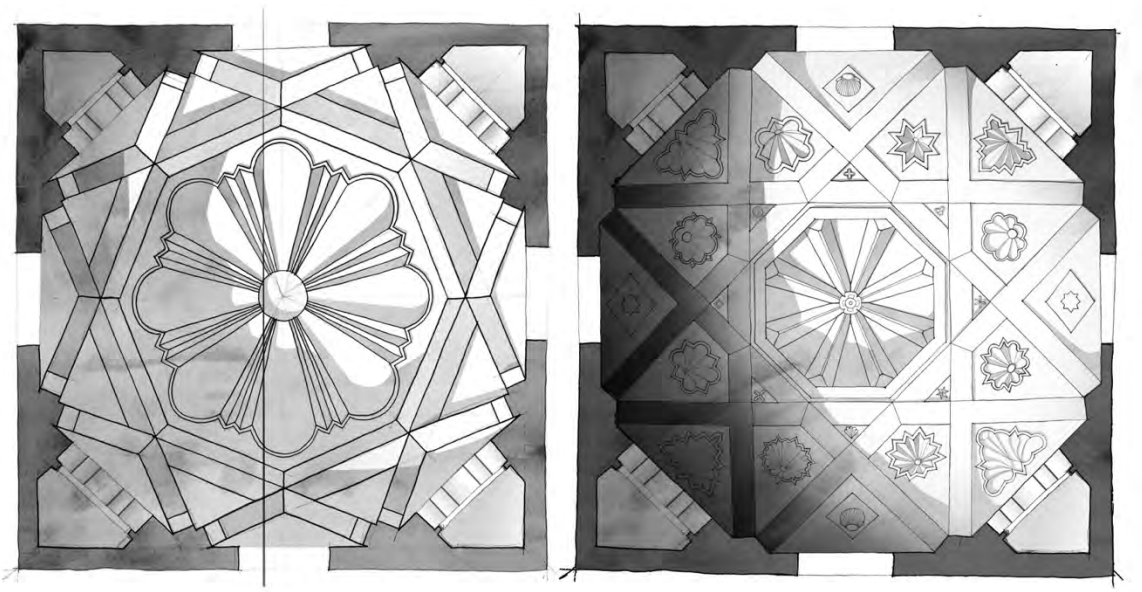

Figure 1: Central bay (left) and side bay (right) of the maqsura in Cordoba's mosque (Spain, 916). Sketch and watercolour by Giuseppe Mazzone (central bay) and Katarzyna Baczynska (side bay.

In the maqsura's central bay (Fig. 01a), a drum sits on top of the arcades, transitioning the squared profile of the bay into an octagon. The transition is not perfect as the diagonal sides of the polygon cantilever above the bay's corners. On each side of the drum a five-foiled arch hosts a window open along the maqsura's peripheral walls. At the corners, squinches

are decorated with muqarnas [22]. From each vertex of the drum paired columns sustain the ribs framing the dome. The bases for these supports protrude from the bay's profile while the transition between the columns and ribs (which are bigger in size than the columns) uses a pulvinus. The resulting dome is composed by eight intersecting ribs concentrating the main thrusts at the ribs' intersection. As a result, a traditional heavy dome is transformed into a light shell with a chance to open windows in the filling areas between ribs. The ribs, however, highlight the linearity of Cordoba's composition. In each of the structural nodes folding lines result by the angling of each rib towards its receiving supports – a solution later solved by Guarini in the seventeenth century by describing the ribs upon a sphere. Yet, the regularity of folding lines in Cordoba's central bay is remarkable.

In the side bays, the maqsura uses a different setting for its dome (Fig. 01b). The drum is still set upon an octagon although this time a single column occupies each vertex of the polygon. The columns still cantilever from their supporting structure while their pulvini grow in size to accommodate two adjacent ribs springing from each support. The ribs span across an area corresponding to three sides of the octagon instead of two as in the previous example. The number of structural nodes is therefore doubled and organized on two levels, each one hosting eight nodes. In the lower nodes, the ribs intersect at 90 degrees while in the upper ones the intersection's angle register 120 degrees. Once more, folding lines appear in each intersection. The overall setting appears less refined than the solution in the maqsura's central bay. Even the decorative apparatus reduces in details, with floral carvings in each filling area between ribs.

Interlaced ribbed domes will continue appearing in Spanish architecture until the late Renaissance and early Baroque although their original Islamic inspirations will slowly transition towards Romanesque and Gothic aesthetics which show an increase of the structural mass [23]. Conversely, similar architectural examples in Northern Africa will transforming interlaced domes into thin lattice structures hiding the actual roofing system. The difference indicates a diverging approach to domes, separating Islamic and European architecture. The latter presents a strong link between structural devices and decorative elements [24] with domes conceived as ornamental details executed through a carpentry framing covered with stucco or mastic [25]. In European architecture, instead, domes reflect a heritage tied to Roman construction techniques – masonry structures constituting the actual roof for a building. The Spanish-Arabic iteration sits in between these two opposites offering special attention to decorative details more than technical executions [26].

The dome from the Great Mosque in Tlemcen (Algeria, mid-thirteenth century) identifies the Islamic use of interlaced ribbed domes. (Fig. 02) In this example a squared bay transitions to a dodecagon although only four of the polygon's sides cantilever. Each vertex of the dodecagon hosts two ribs separated by a small pilaster – each rib spanning five sides of the polygon. The increased number of nodal intersections is organized on four levels, each one containing twelve nodes. The intersections still present folding lines although their visibility is reduced by slandering the ribs (acquiring a "T" profile in section). Additionally, the whole surface of the dome is removed of its weight by delicate carvings hiding the structural walls along the bay's perimeter and the windows open into them.

On opposition of this example, the Church of the Holy Sepulchre in Torres del Rio (twelfth century) displays a Romanesque approach. (Fig. 03) The octagonal setting of the dome is composed of paired ribs spanning along three sides of the polygon individuating a second smaller octagon on top of which a hemispherical dome rest. However, this time the ribs do not spring from the vertexes of the octagon but from the middle point of its sides. An additional set of ribs starting from the vertexes of the octagon interrupts upon reaching the intersection nodes of the main structure. The resulting 3-ribbed node is intentionally not solved: the two ribs from the main frame intersect with a folding line while the singular rib from the polygon's vertex joins the intersection on a receding plane. The effect promotes the illusion of two overlapping systems: the main interlaced ribbed dome, disconnected from the building's main orientation, and a second ribbed structure hidden behind the previous one and anchored to the building corners. The device appears as an

attempt to suggest volumetric complexity in a setting where the composition is stripped by decorative patterns and windows.

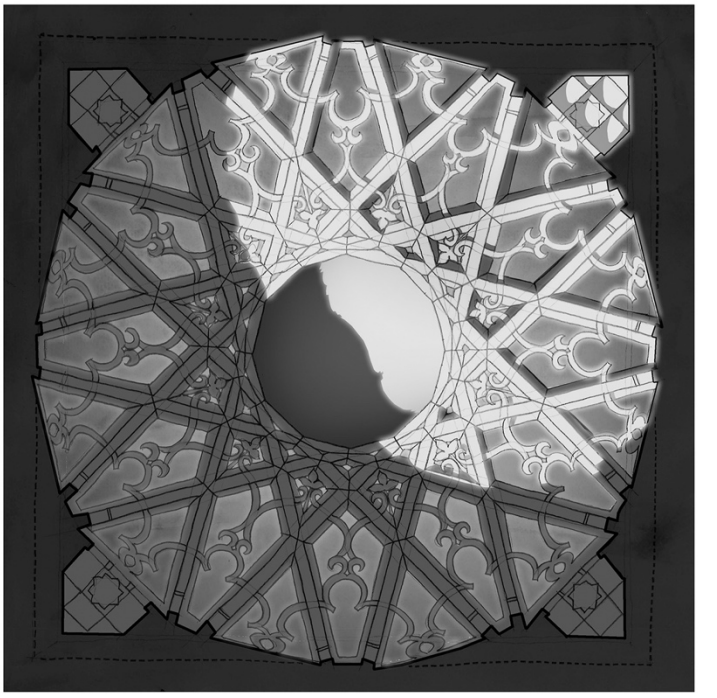

Figure 2: Plan of the dome in the Great Mosque in Tlemcen (Algeria, mid thirteenth century). Sketch and watercolour by Giuseppe Mazzone

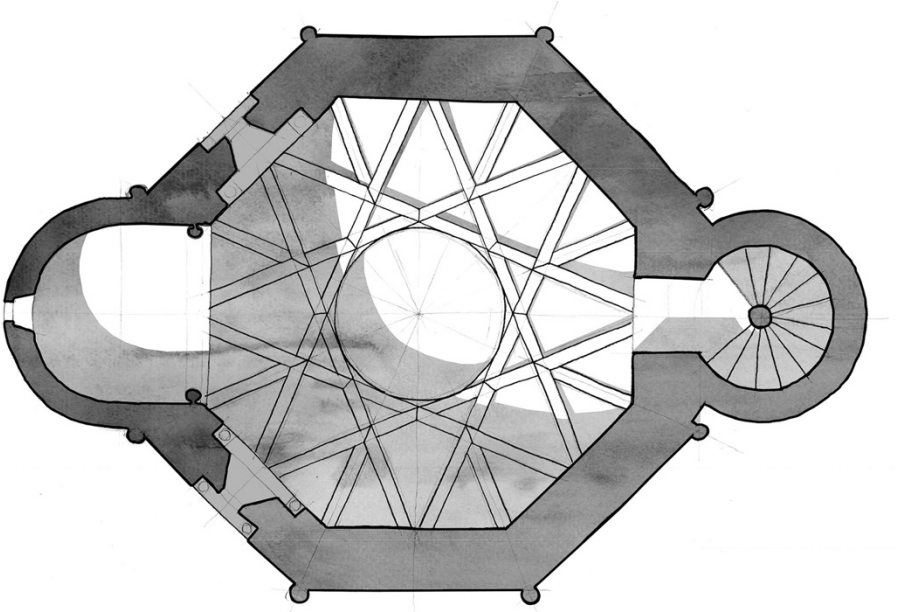

Figure 3: Plan of dome in the Church of the Holy Sepulchre in Torres del Rios (Spain, twelfth century). Sketch and watercolour by Giuseppe Mazzone

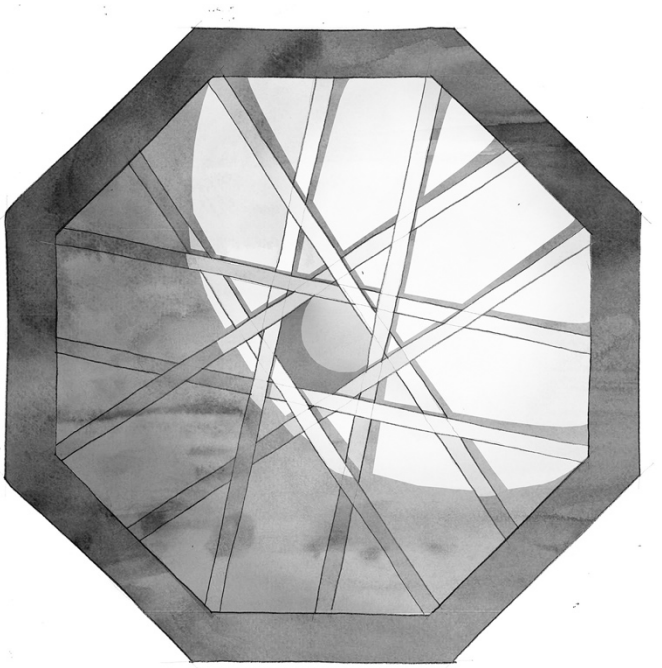

Figure 4: Plan of the dome for the Salamanca's Chapter House (Spain, twelfth-fourteenth century). Sketch and watercolour by Giuseppe Mazzone

A similar approach appears in Salamanca's Chapter House (included in the Old Cathedral's complex built between the twelfth and the fourteenth century). (Fig. 04) The dome is set up once again upon an octagon although its ribs span across the room following a skewed path. After springing from one of the octagon's vertexes as in previous examples, each rib skips three and a half vertexes ending in the middle point of the octagon's side instead of in one of its vertexes. The solution increases the number of overall ribs from eight to sixteen. The effects suggest the illusion of a dome subjected to helicoidal torsion. The solution still lacks refinement – an effect even more visible because of the decorative patterns carved on each rib. These very same elements appear excessively slender to perform a structural role which is now supplied by the dome's filling areas.

The progressive reduction in size of the ribs will, over time, direct Spanish interlaced ribbed domes towards Gothic structures. Ribs will still be present in these compositions moving along curvilinear patterns – their structural role now combined with filling areas. The exponential complexity in these configurations will refine structural nodes, becoming a major focus in Spanish Stereotomy.

An example of this bridge between Gothic and Islamic heritage is Burgos Cathedral. The building was started during the thirteenth century with further work executed between the fifteenth and sixteenth century. Among these later additions, interlaced structures appear in the Chapel of the Constable and in the church's central bay. The Chapel of the Constable (Fig. 05a) adopts an octagonal shape with two ribs per vertex – each rib connected to the vertex opposite to its springing point. However, upon reaching their first structural node, the ribs interrupt generating a new framework which repeats the previous pattern. Once again, this second pattern interrupts upon the rib's first intersection. From these last nodes the ribs reach the centre of the dome, thus closing the composition. As in Romanesque examples, the ribs are now extremely slender, highlighting the thrusting lines in the dome without performing a direct structural role. The filling areas indicate a clear advancement in construction techniques – their arched surfaces describe a hemispherical shell carved into irregular

lozenges. Likewise, at the core of the composition the dome releases its mass by presenting screens punctured in geometric patterns.

In the central bay of the same cathedral (Fig. 05b), the dome follows a similar configuration although this time the screened surfaces further expand, engulfing the entire structure.

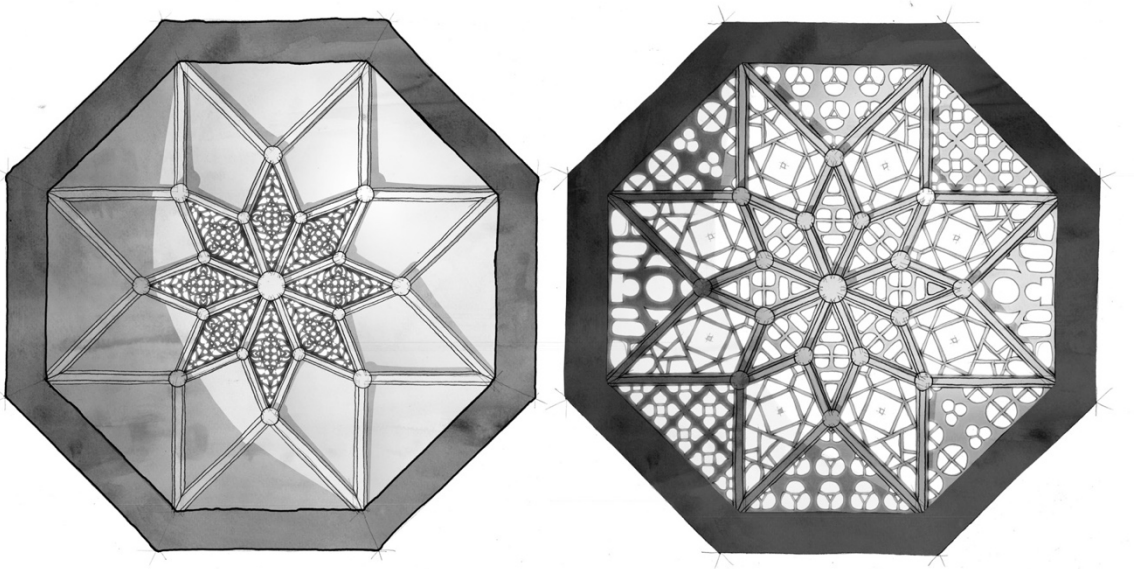

Figure 5: Dome in the Chapel of the Constable (at the left) and above the crossing bay (at the right) in Burgos Cathedral (Spain, fifteenth-sixteenth century). Sketch and watercolour by Giuseppe Mazzone

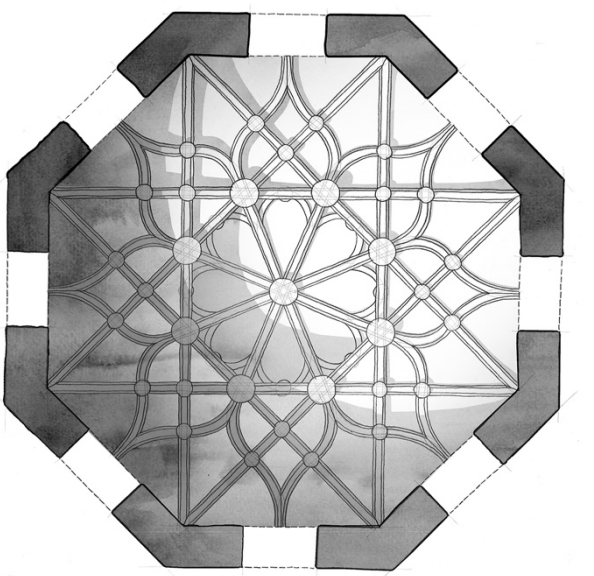

Figure 6: Plan of the dome in the Cathedral of Santa Maria de Mediavilla in Teruel (Spain, 1537). Sketch and watercolour by Giuseppe Mazzone

In later examples light sources will gradually disappear from the dome's surface while the overall setting will transition towards Renaissance forms. The ribs themselves cement their structural role according to Gothic principles gracefully moving along the vaults and domes. The lantern tower from the Cathedral of Santa Maria de Mediavilla in Teruel offers an interesting example for this new iteration of interlaced ribbed domes. (Fig. 06) Designed in 1537 by Juan Lucas Botero, the lantern's dome links the keystone of the window in the dome's lower tier to the oculus above where a second interlaced structure rest. The framing for this second structure appears in line with Renaissance structures presenting ribs directed towards the dome's centre. Compositional challenges in the structure are increased by the presence of curved ribs although their intersections are conveniently hidden from view by decorative elements. As in Romanesque examples, light no longer filters through the dome itself but radiates from windows open along the dome's spring plane.

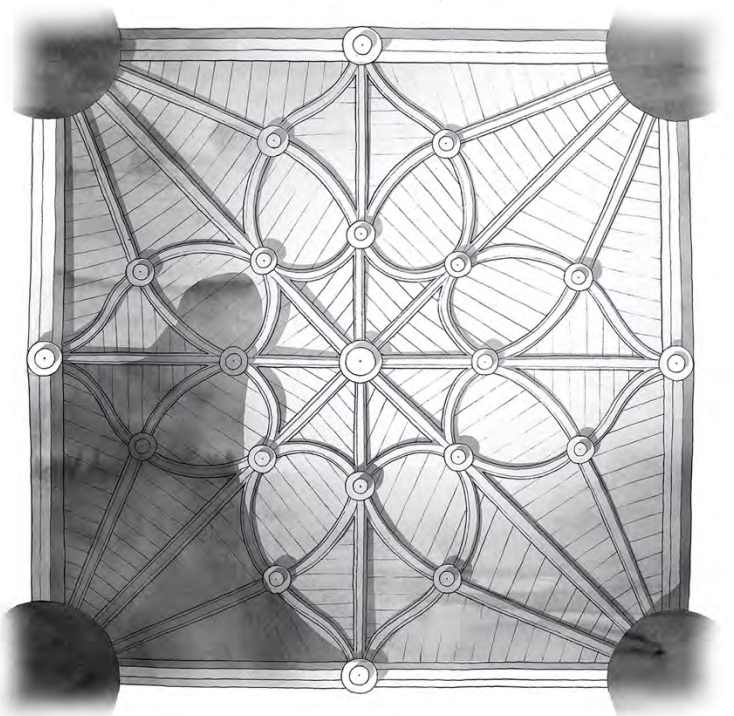

Figure 7: Altar's vault in the church of San Nicholas in Priego, Cuenca (Spain, sixteenth century). Sketch and watercolour by Katarzyna Baczynska

The shift towards Renaissance aesthetics can be traced in the composition of Spanish vaults. The sixteenth century church of San Nicholas in Priego (Cuenca, Spain) presents a wonderful example in its altar vault, where interlaced ribs describe a flowery pattern (Fig. 07). The ribs are strategically located to hide folding lines along the ridges of the cross vault (whose profile is close to acquiring the spherical profile of a web vault). Intersection nodes are still partially hidden behind joints while the composition is stripped of any decorative element following the principle of structural decoration pursued by Stereotomy. It is during this time (mid-sixteenth century) that Spanish treatises on the topic start appearing. Their main focus will approach the geometric rigour of its applications, rejecting empirical methods based on the manipulation of geometric forms learned by rote in the shops [27]. Alonso de Vandelvira represents one of the major contributors on these applications. Most of his applications, still rooted in Gothic architecture, are based on examples from the works of Andres de Vandelvira [28], Alonso's father. His most representative works are the vaults for the Assumption of the Virgin Cathedral in Jaen (Andalusia, Spain), which mark the final transition of Spanish interlaced

structures from Gothic forms to pure Renaissance themes. Ribs disappear, becoming embedded directly in the vault's structure as chromatic decorations dictating the structural composition of the vaults. (Fig. 08) Fusing decorative and structural patterns, Andres de Vandelvira creates in Jaen a variety of intricate patterns perfectly adherent to Stereortomic principles.

Figure 8: Transept vault in Jaen's Cathedral (Spain, sixteenth century) by Andres de Vandelvira. Sketch and watercolour by Katarzyna Baczynska

With the rise of the sixteenth century interlaced ribbed domes abandon the Iberian Peninsula to resurface once more during the late seventeenth century in the works of the Italian architect Guarino Guarini. It is not clear how Guarini became acquainted with this typology as his life accounts do not mention any direct link to Spain. However, as a teacher for the Theatine order – a monastic group working in direct contact with the papacy – Guarini spent most of his life in Messina (Sicily). At that time the southern territories of the Italian peninsula were under Spanish rule with Messina hosting the summer residence for the Spanish Royal family. Therefore, the city engaged in a constant dialogue with the Iberian Peninsula and, eventually, with its architectural heritage. The theme of interlaced ribbed domes pervades Guarini's designs where Spanish precedents have been critically approached and re-interpreted. The dome for San Lorenzo in Turin presents an astonishing resemblance to the maqsura's domes in Cordoba's mosque.

The major innovation found in San Lorenzo (and in most of the other designs by Guarini) consists in the substitution of a polygonal setting for a circular one. (Fig. 09f) Thanks to this new configuration, the ribs are now radially distributed around the dome's springer plane, removing their protrusion from the bay's profile. While spanning across the bay, the ribs move along a spherical surface witnessing a co-planar intersection when merging into structural joints. In consequence, the folding lines plaguing Spanish examples disappear. The updated configurations also experience a structural revision: each rib is now executed according to Roman traditions with Stereotomic applications concentrated

into structural nodes only. This causes a lessening in the compositional refinements both French and Spanish Stereotomy aimed to introduce. Windows open again directly in the dome following the profile of the interlaced structure. At the top of the composition, a polygonal oculus becomes the setting for a second structure sustaining its own interlaced ribbed dome (reminiscent of the central bay from Cordoba's *maqsura*) on top of which the church lantern rests.

The innovations performed by Guarini on the typology appear throughout his designs with multiple iterations. (Fig. 09) The classical octagonal is substituted by new profiles such as triangles (as in the pendentive for the Chapel of the Holy Shroud in Turin, 1668-1694) (Fig. 09a), pentagons (San Gaetano in Nice, 1670) (Fig. 09b), and hexagons (Church of the Somaschi Fathers in Messina, 1660-1662 [Fig. 09c] and the presbytery from San Lorenzo in Turin, 1668-1687 [Fig. 09d]). Even when maintaining an octagonal setting, the typology always displays innovations with ribs skipping one vertex (as in the lantern from San Lorenzo in Turin) (Fig. 09e), two vertexes (main dome in San Lorenzo) (Fig. 09f), or even creating a double tier structure (Sainte-Anne-la-Royale in Paris, 1662) (Fig. 09g). Additional transformations also re-invent the typology turning the dome into a conical structure composed by overlapping tiers of arches, each tier springing from the keystone of the arches in the tier below (Chapel of the Holy Shroud in Turin, 1668-1694). (Fig. 09h)

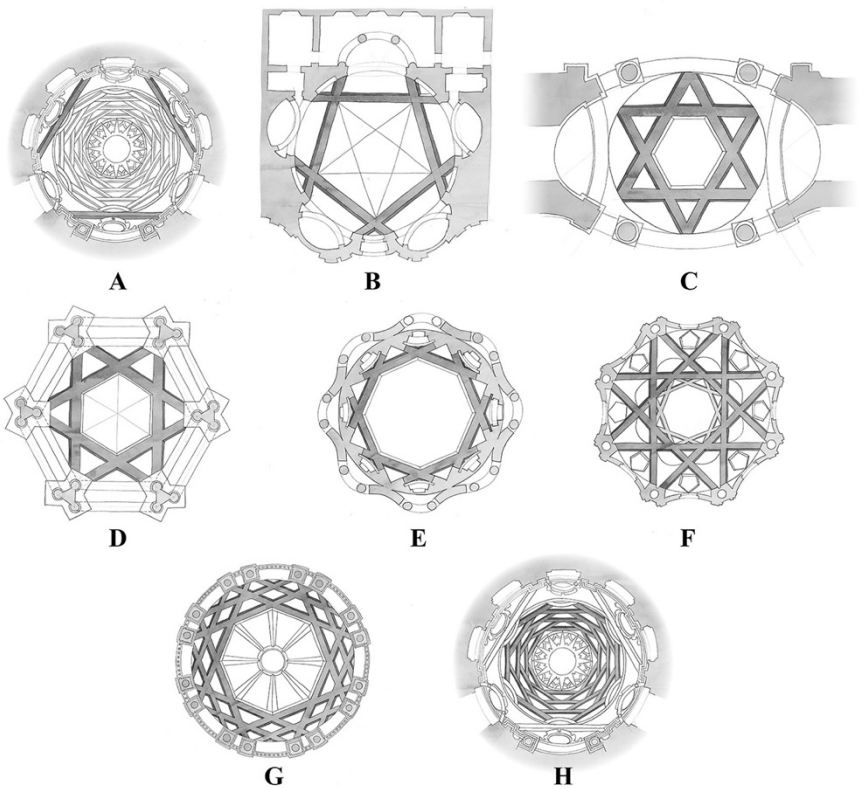

Figure 9: Guarini's variations on interlaced ribbed domes: A) Pendentive in the Chapel of the Holy Shroud, Turin; B) Dome in San Gaetano, Nice; C) Dome in the Church of Somaschi's Fathers, Messina; D) Presbytery, E) Lantern, F) main dome in San Lorenzo, Turin; G) Dome in Sainte-Anne-la-Royale, Paris; H) Main dome in the Chapel of the Holy Shroud, Turin. Sketch and watercolour by Giuseppe Mazzone

Interlaced ribbed domes will make sporadic appearances before abandoning the Italian architectural stage in the mid-eighteenth century. The main reasons for this departure relate to their structural complexity and their Gothic-Islamic roots. Italian architecture did not fully embrace Stereotomy, opting instead to expand Roman construction principles. Likewise, Italy had limited exposure to Gothic architecture with sporadic appearances such as the Duomo in Milan.

After Guarini the typology appears once more in the works of Bernardo Vittone (1704-1770). An admirer of Guarini's work, Vittone will continue to experiment on interlaced domes designing the Visitation Sanctuary in Vallinotto (Carignano, 1738). (Fig. 10) The composition develops upon a hexagonal setting in a structure composed by three superimposed layers. Paired ribs spring from the hexagonal corners skipping one vertex in their spanning the bay (first layer). The polygonal oculus identified by the intersecting ribs opens into a hemispherical dome (second layer) whose circular oculus reveals a raised arch dome (third layer) – the sanctuary's roofing system. Windows hidden between the second and third layer of the composition filter the light coming in the sanctuary creates the illusion of shells levitating above the building.

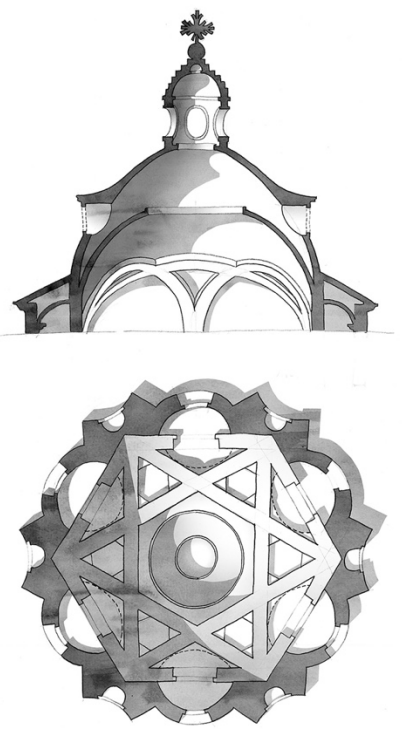

Figure 10: Plan and section of the dome in the Visitation Sanctuary in Vallinotto (Carignano, 1738) by Bernardo Vittone. Sketch and watercolour by Giuseppe Mazzone.

Vittone's multi-layered composition further expands the typology by introducing structural devices responding to the Baroque's scenography demands. The surfaces of the dome are covered by *frescos* with the only exception being the ribs. The resulting effect enhances the lattice structure by covering its filling areas with colours and imagery while leaving the ribs unadorned – an inversion from the Baroque tendency to hide structural elements in the building mass or through a lavish decorative layer.

Conclusions

With Vittone the architectural chapter of interlaced ribbed domes reaches its conclusion. Hints of their spatial properties can still be perceived in Baroque advanced configurations involving intersected vaults. Here ribs may appear once more curving along the vaults surfaces or highlighting their structural joints. While the typology might have reached its final destination, the memory of it evokes a moment in time where cultures were able to set aside their differences to establish an architectural language based on cultural freedom and coexistence. The unique results reached in Spain are among the most interesting examples of this phenomenon. The resurfacing of interlaced ribbed domes in Italy during the seventeenth century certainly improved on its executions and final results. The attempt, however, clashed against a culture deeply rooted in an architectural heritage from which the Renaissance bloomed. Guarini's work, while remarkable, was not able to ignite the same spark lighted in Cordoba almost a thousand years before. Nonetheless, the message promoted was still the same: a boundless flow of human creativity through geographical areas, cultures, and time.

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