FOURTEEN-POINTED **STAR TECHNIQUES** IN SUNGURBEY MOSQUE, **BAYEZID MOSQUE** AND A UNIQUE DESIGN IN **SÜLEYMANİYE MOSQUE**

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ABSTRACT

This article will be tackling two different fourteen-pointed star patterns and the formation of a particular application containing a fourteen-pointed star all of which are located in Sungurbey Mosque, Bayezid Mosque and Süleymaniye Mosque. First two designs are in accordance with the production method introduced by Bonner and Pelletier. However, the design on the interior ceiling of the shadırvan in the Süleymaniye mosque seems to deviate this method. In this article we will explain in detail the principles of the formation of this design and the steps to be taken to accommodate it to the methodology introduced in the aforementioned article.

Keywords: Geometric Pattern, Islamic Geometric Design, Fourteen-pointed star, Geometry and Art, Sungurbey Mosque, Bayezid Mosque, Süleymaniye Mosque.

ÖZET

SUNGURBEY CAMİİ, BAYEZİD CAMİİ' NDE ONDÖRT KÖŞELİ YILDIZ TEKNİKLERİ VE SÜLEYMANİYE CAMİİ' NDEN TEKİL BİR DESEN

Bu makalede, Sungurbey Camii, Bayezid Camii'nde bulunan iki farklı on dört köşeli yıldız deseni ve Süleymaniye Camii'nde bulunan on dört köşeli bir yıldız içeren özel bir uygulamanın oluşturulması ele alınacaktır. İlk iki tasarım Bonner ve Pelletier tarafından sunulan üretim yöntemine uygundur. Ancak Süleymaniye Camii'ndeki şadırvanın iç tavanındaki tasarım bu yönteme uymuyor gibi görünüyor. Bu makalede, bu tasarımın oluşum ilkelerini ve makalede anlatılan metodolojiye uyum sağlamak için atılacak adımları ayrıntılı olarak açıklayacağız.

Anahtar kelimeler: Geometrik Desen, İslâmî Geometrik Desen, Ondört köşeli yıldız, Geometri ve Sanat, Sungurbey Camii, Bayezid Camii, Süleymaniye Camii

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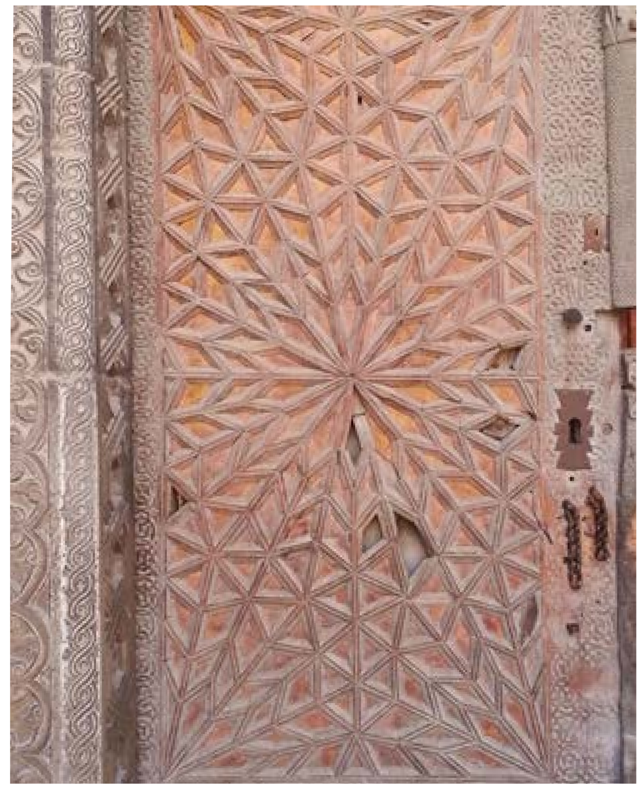
Figure 1: The wooden door in Sungurbey Mosque (Serap Ekizler Sönmez)



Introduction

The making of a tetradecagon begins with a heptagon. Two intertwined heptagons give us a tetradecagon. Seven is a prime number. Because its interior and exterior angles are fractioned numbers, making designs with heptagons can be considered to be difficult. An approximate method to draw a heptagon within a circle by a ruler-compass construction was provided in one of Abu'l-Wafa Al Buzjani's(d. 998) works which is listed among the primary sources (Haddad, 2015).

This article does not focus on the heptagon or seven-pointed stars, which were thoroughly investigated in Bonner and Pelletier's (2012, pp.141-148) article. Rather, in a comparative fashion, I will discuss the formation of fourteen-pointed found in three examples present in Sungurbey Mosque, in Bayezid Mosque and in Süleymaniye Mosque in Turkey, by making references to the polygonal structures that are studied in the aforementioned article. Throughout the article, I give detailed descriptions for generating all of the sample patterns.

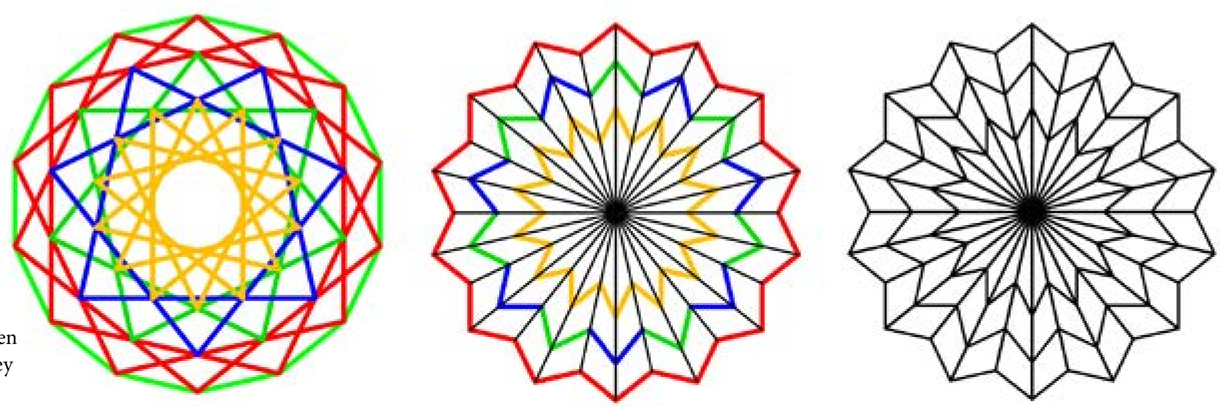
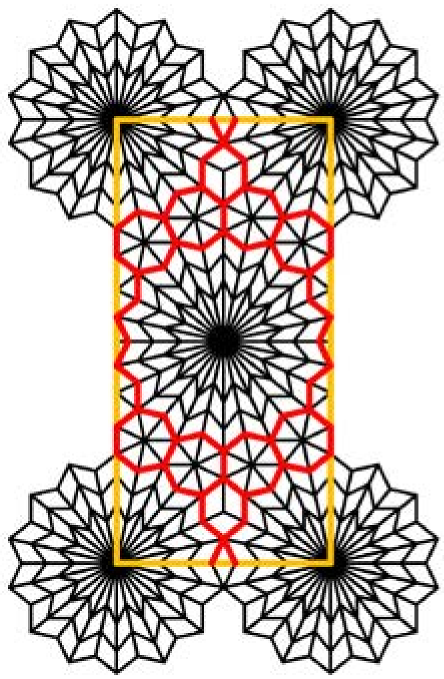
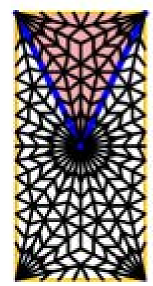


Figure 2: The fourteen-pointed star on the wooden door of Sungurbey Mosque (Serap Ekizler Sönmez)

Two Kundekari Patterns From Anatolia

Kundekari is the art of making geometrical patterns by interlocking many wooden pieces together without using a glue or a nail. The two designs to which we will refer are made with the kundekari technique. Constructed in the transition period between Anatolian Salukis and Ottomans, the wooden door of Sungurbey Mosque (14th century) in Niğde contains a fourteen-pointed star at its center and ¼ of a fourteen-pointed star on the four corners of the door wing (Figure 1). This layout is also in accordance with the classic kundekari techniques that exist in the mosques of Mimar Sinan. Similarly, in the classic polygonal applications, ¼ of the fourteen-pointed star that is located in the center is placed on the four corners of the door wing. Three different sizes of a fourteen-pointed star, generated from two interlocking seven-pointed stars within a tetradecagon can be seen in Figure 2.





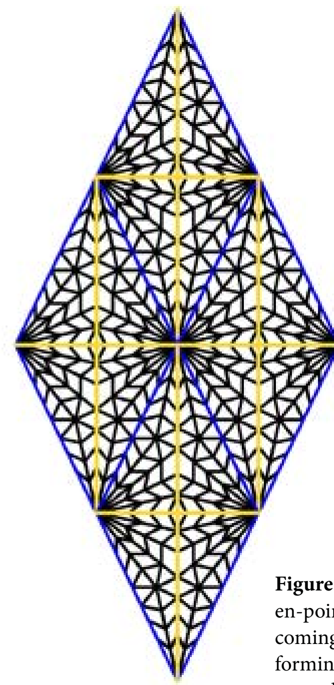


Figure 3: Fourteen-pointed stars coming together forming rhombuses and as a result extending the pattern (Serap Ekizler Sönmez)

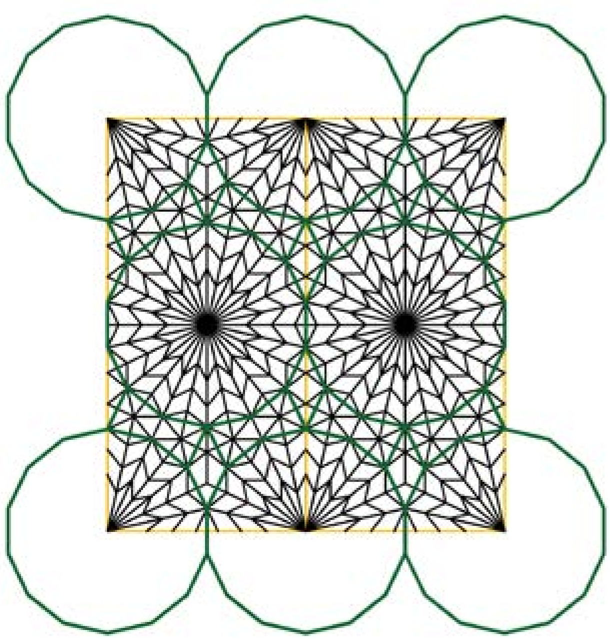


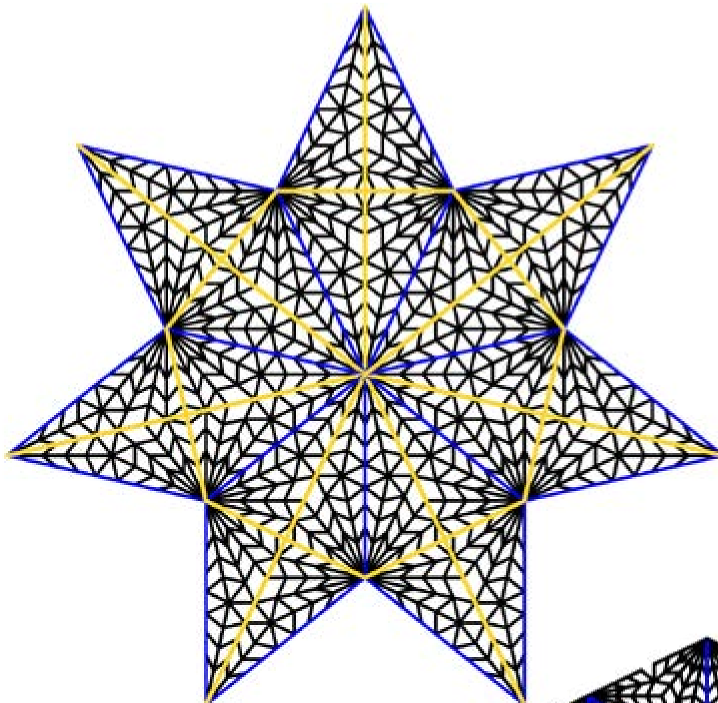
Figure 4: Polygonal shape of the pattern (Serap Ekizler Sönmez)

The pattern can infinitely be extended if we translate the pattern on the door which we take as a unit cell. When we connect the door corners with the center point of the central star, half of the resulting triangular area will be the smallest unit that we can use to extend the pattern to infinity. We arrive at the rhombuses by applying mirror symmetry to this triangular area. As it is seen in many Ottoman pentagonal kundekari examples, the pattern can be repeated by the translation of the rhombus (Figure 3).

In all pentagonal wooden techniques if the entire surface of the wooden wing is considered a unit cell, a surface can be covered with a tessellation of that pattern. Or, it is also possible to cover the surface by applying glide reflection to the triangular area between the corners and the center as seen here. Both of them give us the same result (Castera, 2011).

There are many methods for creating Islamic tiling with a given underlying structure. Polygonal technique helps us understanding geometric structure of patterns. For this technique, every single part of a pattern has a polygon that covers it as a shell does. Bonner is a strong proponent of this technique and having worked on it for years and in his soon to be published book, he studies polygonal structures of hundreds of patterns (2003, pp.1-12). As for the computer application of this method, it is developed by Kaplan (2005, pp.177-186). Polygons given here are; tetradecagon, bow tie and rhombuses (Figure 4).

The stars that are located inside and at the corners of the rhombus are as 2/14 and 5/14 But here, from the left and the right corner, the line of the rhombus cuts the star straight from the middle. In other words, there is a half corner piece on one side and another half corner piece on the other side. Another interesting thing about the system is, that the total



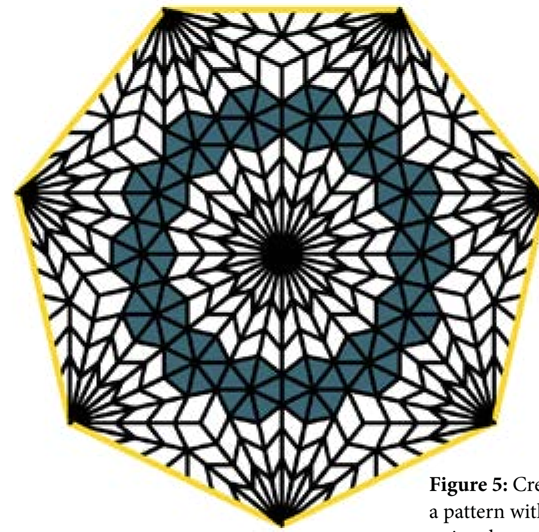


Figure 5: Creating a pattern with rotational symmetry (Serap Ekizler Sönmez)

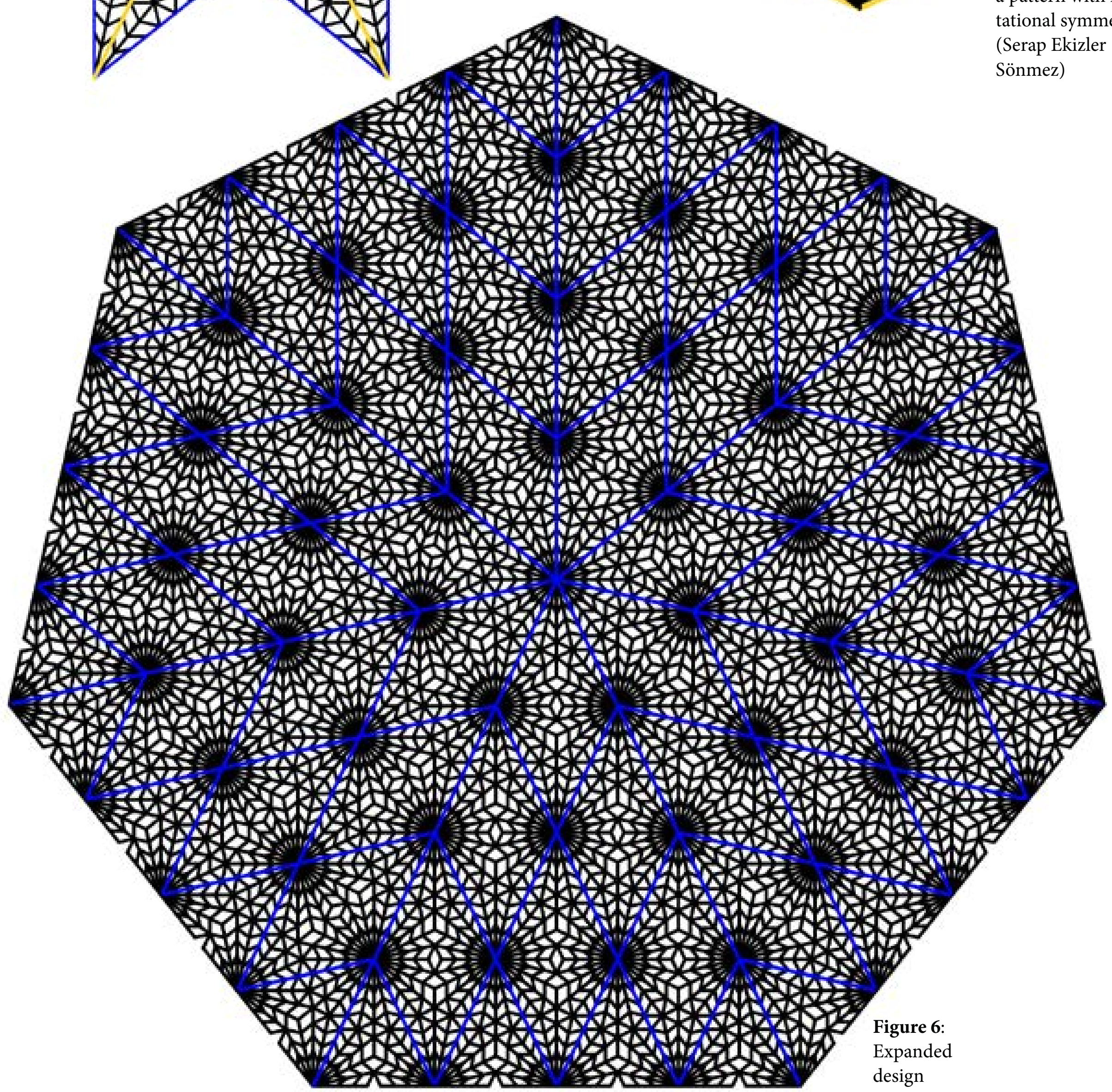


Figure 6: Expanded design

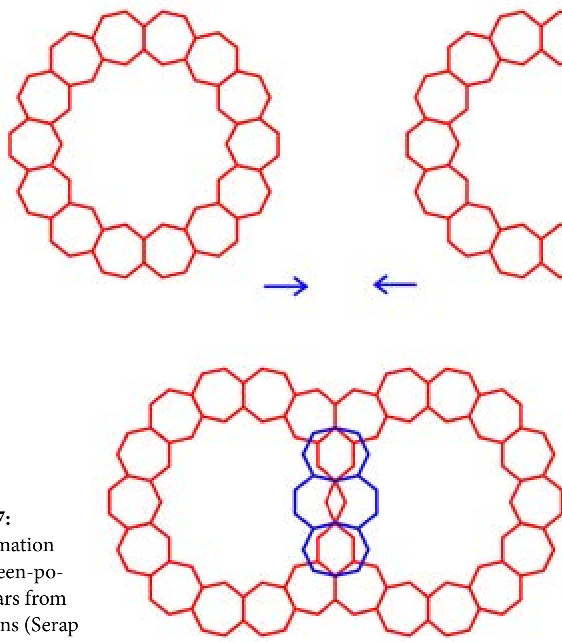


Figure 7: The formation of fourteen-pointed stars from heptagons (Serap Ekizler Sönmez)

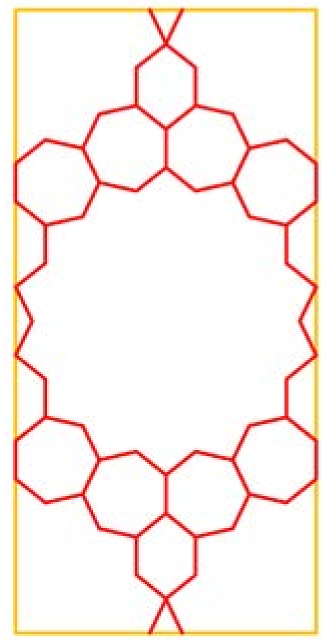


Figure 8: The main structure of the door design of Sungurbey Mosque (Serap Ekizler Sönmez)

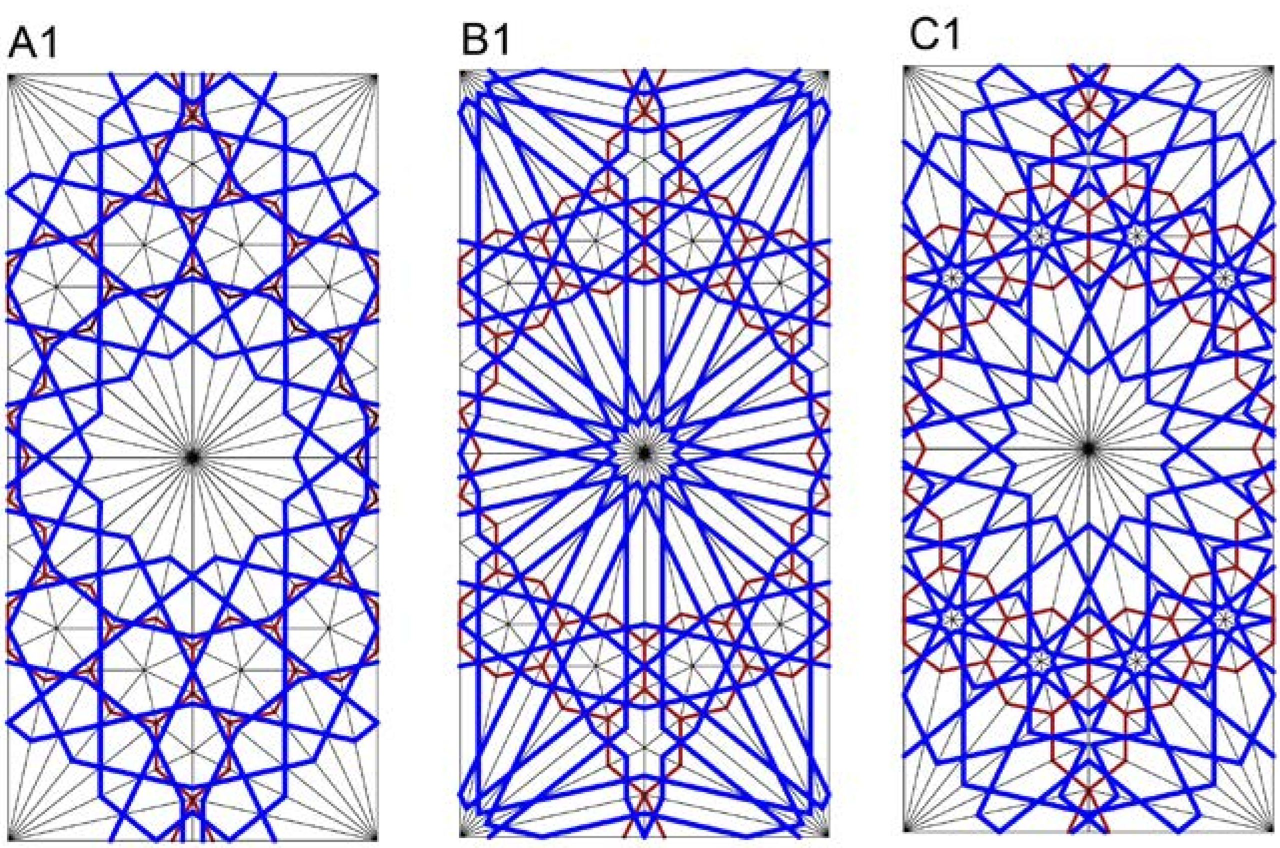


Figure 9: New designs derived from the design of the door of Sungurbey Mosque (Serap Ekizler Sönmez)

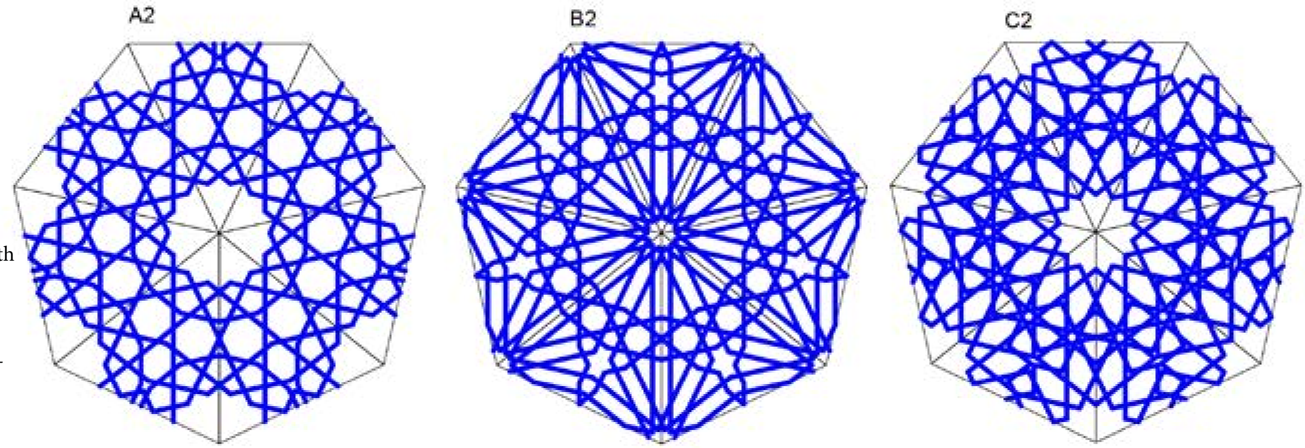
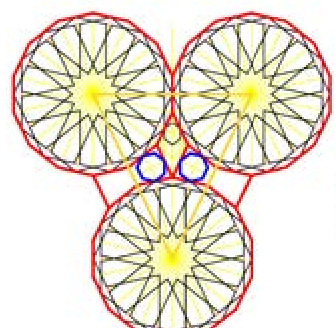


Figure 10: New designs with the rotational symmetry of the design from the door of Sungurbey Mosque (Serap Ekizler Sönmez)

Figure 11: Beyazid Mosque, wooden door (Serap Ekizler Sönmez)



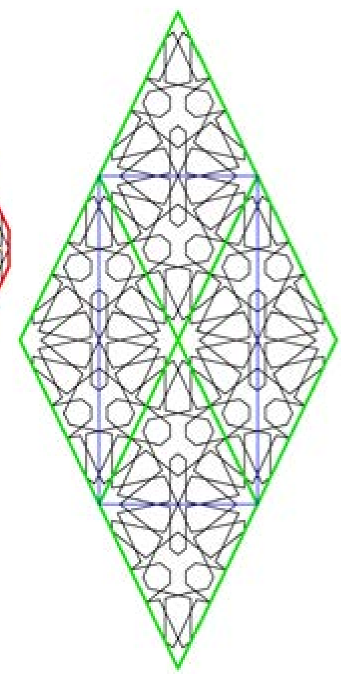
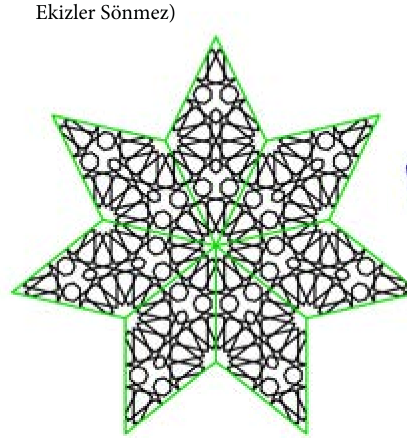


Figure 12: Extension of the rhombuses and the polygonal structure (Serap Ekizler Sönmez)



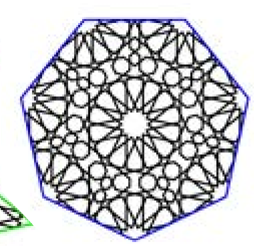


Figure 13: The pattern obtained using rotational symmetry (Serap Ekizler Sönmez)

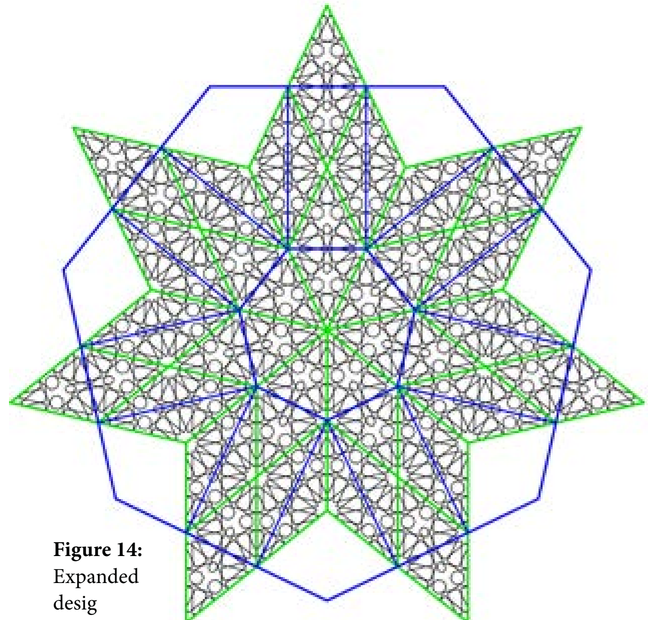


Figure 14:
Expanded
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(Serap Ekizler
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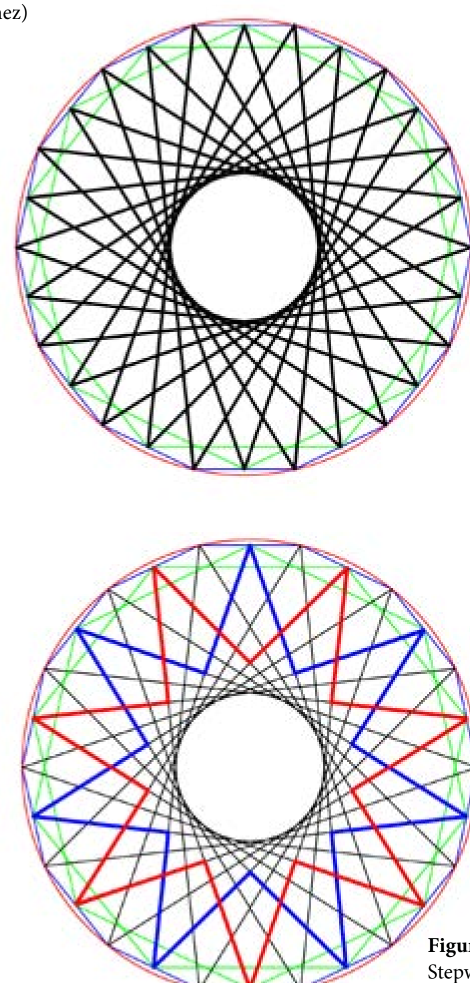


Figure 15 a-b:
Ceiling of the Shadırvan of Suleymaniye Mosque (Serap Ekizler Sönmez)

Figure 16:
Stepwise occurrence of the star in the Shadırvan (Serap Ekizler Sönmez)

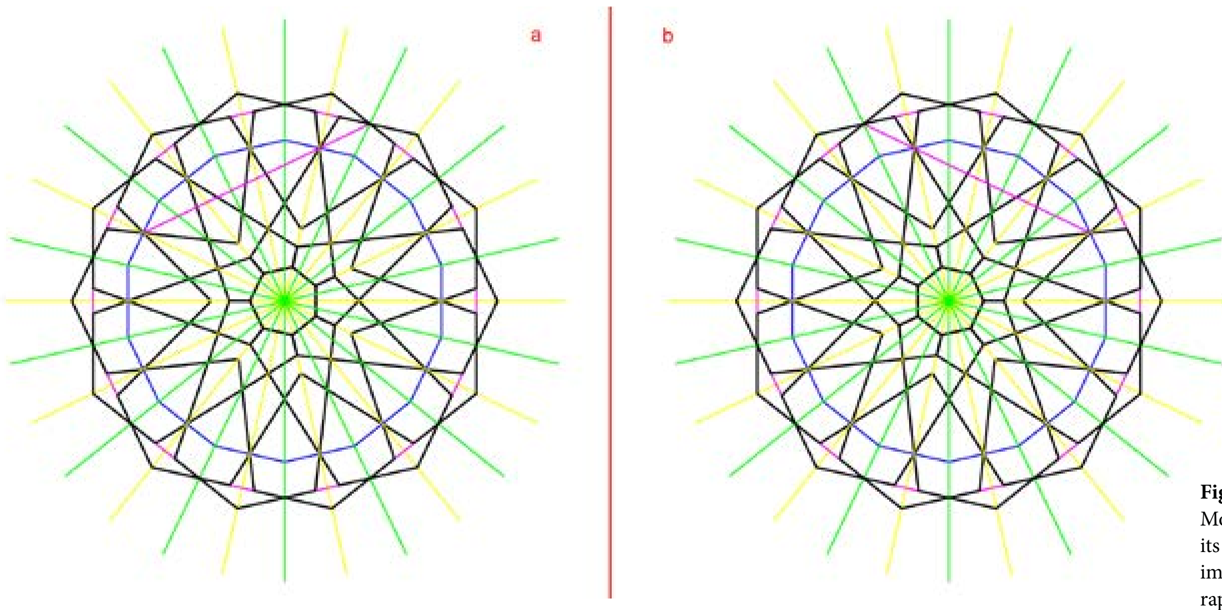


Figure 17: Motif a, and its mirror image b (Serap Ekizler Sönmez)

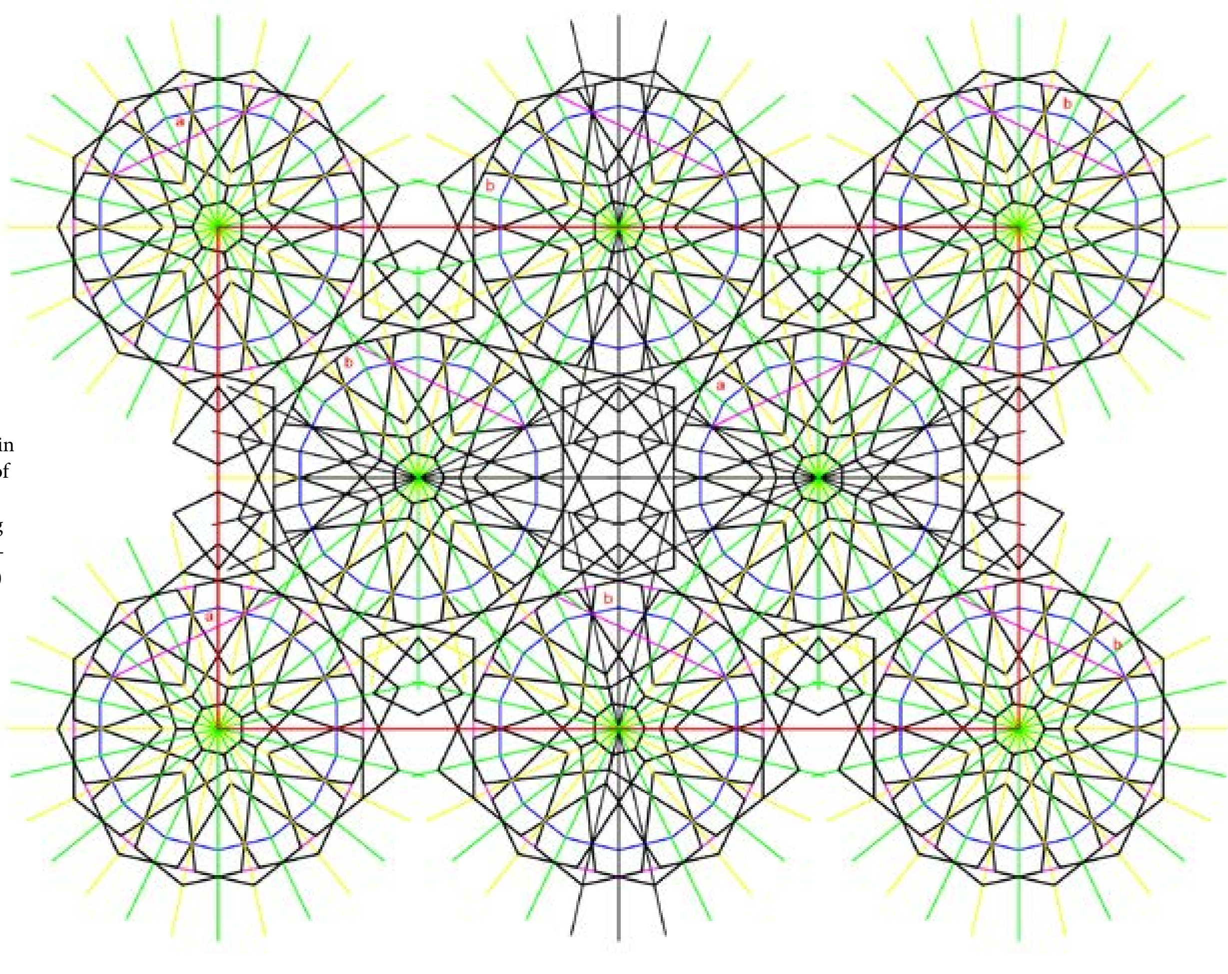
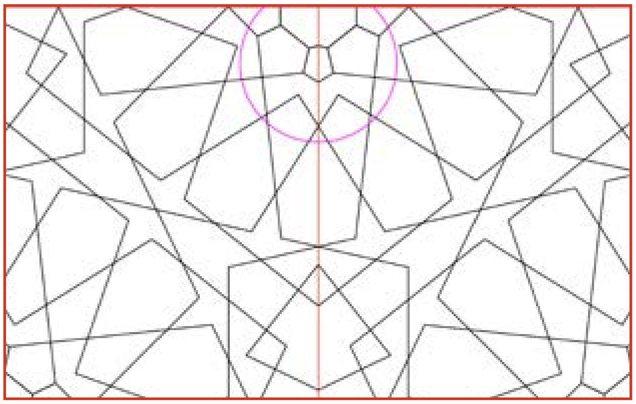


Figure 18: Plain tiling of the stars in the design of the Shadırvan's ceiling (Serap Ekizler Sönmez)

Figure 19:
The problem
(Serap Ekizler
Sönmez)



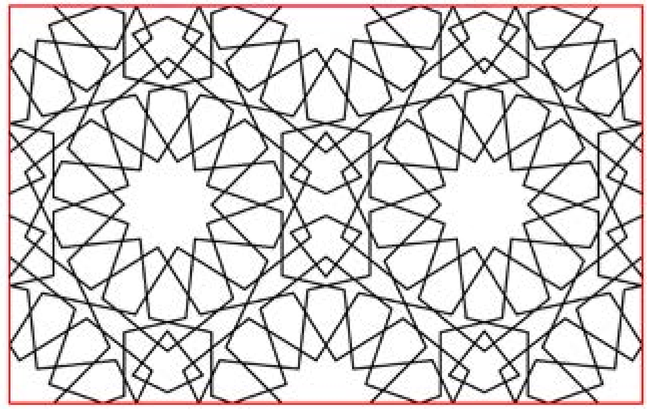


Figure 20: The pattern on the ceiling of the Shadırvan and its state after removing the pentagons at the center (Serap Ekizler Sönmez)

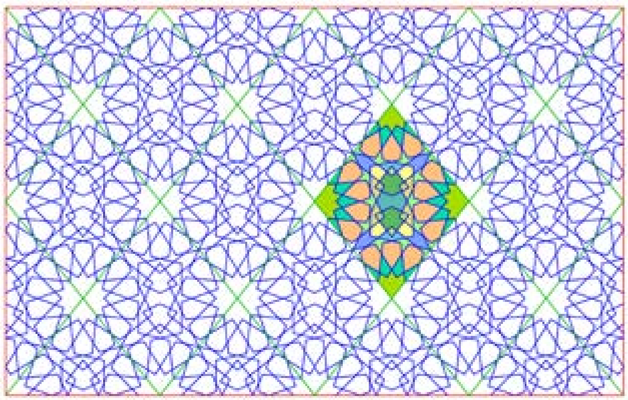


Figure 21: Extension of the pattern to infinity with the help of the rhombuses (Serap Ekizler Sönmez)

of the parts in the wide and narrow corners of the interior of the rhombus is: 3+4=7 and 2+5=7. Although not included in the examples given in this article, there also exist rhombus implementations with 3/14 and 4/14 star pieces.

A different way of forming a design from the main rhombus is to employ rotational symmetry. Thus, an alternative design, like the side surfaces of the Classical period minbar can be developed. The mimbars of the mosques of Mimar Sinan carry examples of such patterns. They are typically polygonal motifs with rotational symmetry (Ekizler Sönmez, 2016). We can create such a rotationally symmetric polygonal motif using the pattern from the Sungurbey Mosque door. Applying the rotational symmetry to the triangular motif rather than the rhombus, the fourteen-pointed stars will be visible on every corner and at the center of the heptagon (Figure 5). Of course, the design with rotational symmetry can also be opened to infinity (Figure 6)

Although the design on the door of the Sungurbey Mosque is applied with the kundekari technique, the geometrical construct of the design is appropriate for the window grid system. In other words, designs with this type of geometry are usually seen in applications in front of the windows where lines are used as the main skeleton and the areas in between these lines are left blank. These panels also serve as a screen in front of the windows. The minber of Şehzade Mosque (16th century) which exhibits a pentagon construct system placed in a circle on its lateral face has one of the most beautiful examples of these designs applied on marble and in a format other than window unlike the usual area of application and the material which is wood. (Ekizler, 2016). The foundation which is used to derive the pattern is used as the pattern itself without continuity in the lines. We can understand this better if we weave the lines. In such a mesh only two lines are expected to intersect, however, for this pattern more than two lines overlap which intrinsically makes it impossible to flow the design in the shape of a weaving.

The circular array of tangent heptagons gives us a fourteen-pointed star. When two of these forms are merged, the heptagons that overlap in between them give us non regular hexagon rhombus - non regular hexagon (Figure 7). This makes up the basis of the design on the door of the Sungurbey Mosque (Figure 8).

What is more interesting is that by using this construction as a polygonal structure three different designs can be made (Figure 9, A,B,C). And by applying rotational symmetry to these designs we can reach at other different designs (Figure 10, A, B, C)

The wooden door (Figure 11) of Beyazid Mosque (15^{th} century), which is currently in Amasya Museum, has 2/14 and 5/14 star pieces on the corners within the rhombuses. The step-by-step formation process is given in Figure 12. The polygonal structure of the pattern is very noticeable here and it is the same as polygonal structure of the pattern in Sungurbey Mosque.

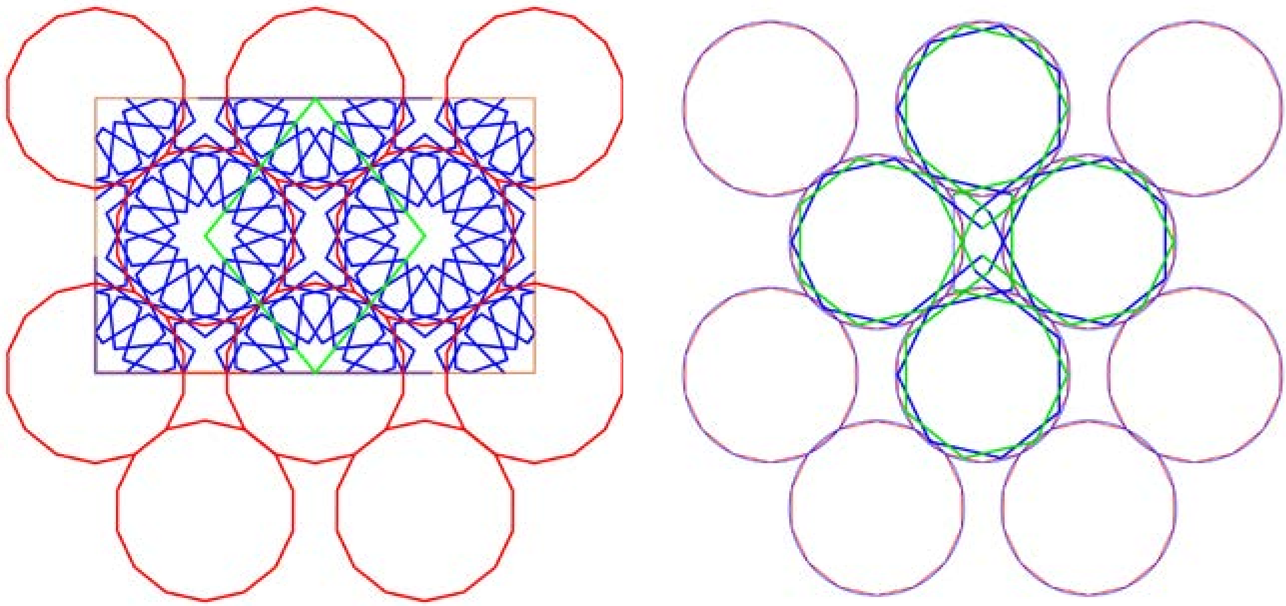


Figure22a-b: The polygonal structure of the pattern and the removal of the cut (Serap Ekizler Sönmez)

In order to extend the pattern to infinity, we translate the rhombuses. We translate copies of the rhombus in two directions in order to extend the pattern to tile the plane. The part that is seen in the rhombus here, gives us the pattern on the door. As seen in the previous examples, it is also possible to apply rotational symmetry to the rhombuses to obtain a different design pair (Figure 13). The design with rotational symmetry can also be expanded to infinity (Figure 14).

A Singular Design on the Ceiling of Shadırvan of Suleymaniye Mosque

Designed by Mimar Sinan the shadırvan of Suleymaniye Mosque (16th century) has a pattern on its ceiling, shown in Figure 15a-b, that consist of fourteen pointed stars. As this design is quite different from the two previous patterns it is also different from the other designs in *history.*

In order to create a star inside the tetradecagon, I drew lines from both the median point and the corner point of the tetradecagon and I singled out two seven pointed stars amongst these lines. These stars are mirror images of each other across a vertical axis. The gap in the center forms a seven-pointed star (Figure 16). Seven irregular pentagons that are in the center, necessitate realization of a trick to reach at the pattern for the formation of the pattern. This trick can be applying a mirror symmetry to the star on a vertical axis. In this design both the star itself and its symmetry was used (Figure 17).

The sequencing is as follows; the first line is a-b-b, the second line is; b-a, the third line is; a-b-b. We reach at the design on the ceiling of the shadırvan by connecting the centers of the stars on the corners in a rectangular way (Figure 18). However, one thing should be taken into consideration; in the two previous examples it was possible to extend the pattern to infinity by translating either the rhombuses or the rectangular part that the pattern gives. But at this point we face a problem. When I brought the pattern together, the part where the polygons in the center came side by side became an incompatible part (Figure 19). The parts that cause this problem are the seven pentagons that are located at the center of the stars. Now I will remove them (Figure 20).

Thus, expanding the pattern to infinity is possible with the use of rhombuses. On the corners of the rhombus there are 4/14 and 3/14 star pieces (Figure 21).

The polygonal structure of the pattern is clear enough. The parts that emerged on the gaps when the four rhombuses come together, gives us the polygonal structure. Nevertheless, I do not think that I am done here. Because the most successful Islamic geometrical design is an uninterrupted design. That is to say that which extends to infinity. This can be also very much relevant to Islamic geometric pattern philosophy. The particle goes to the cosmos and the cosmos goes the particle.

I removed the uneven hexagons that serve as key points to interlock the stars. Because these hexagons were detached from the other lines. In other words, they were independent to the main pattern. The space that emerged after I removed these parts showed me how to proceed, how to intersect the lines and connect the stars. Suddenly, the pattern opened out and naturally extended to infinity (Figure 22a-b). This design is similar to Bourgoin's fourteen-pointed star which was reanalyzed by Bodner (2010, 135-142). But their proportions are rather different.

What is really intriguing is the question of why such a design was not preferred to be presented directly to the beholders by the person who wished it to be located in a monument as such. People, after all, cannot enter and see the ceiling of the Shadırvan. Moreover, due to the water that sprays from the fountains placed on the ceiling, the complexity of the design inside can barely attract anyone. The reason behind this mystery deeply strikes me.

Conclusion

In this article, through three designs from Turkish and Islamic art we examined fourteen-pointed star's structure in detail and found out that even though first two designs were utterly different, because their identical polygonal structure were the same, their multiplying system was the same. Unit cells that are compatible to be repeated by translation, can be also used to produce different designs with rotational symmetry. The last example we have given, namely the implementation on the ceiling of the Shadırvan is not only unique in the history of Ottoman architecture but it is perhaps a unique design even within Islamic arts. However, when I examined the pattern in detail and removed the parts that were preventing the expansion to infinity, I saw it unbend and have the most important trait of the Islamic geometry which is the ability to expanse to infinity.

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