The Gallo-Roman Dodecahedron

Michael Guggenberger

Does your hometown have any mathematical tourist attractions such as statues, plaques, graves, the café where the famous conjecture was made, the desk where the famous initials are scratched, birthplaces, houses, or memorials? Have you encountered a mathematical sight on your travels? If so, we invite you to submit an essay to this column. Be sure to include a picture, a description of its mathematical significance, and either a map or directions so that others may follow in your tracks.

➤ Submissions should be uploaded to http://tmin.edmgr.com or to be sent directly to **Dirk Huylebrouck,** huylebrouck@gmail.com

A previous contribution to this "Mathematical Tourist" column drew attention to the Gallo-Roman dodecahedron (Greek δωδεκάεδρον, from δώδεκα, i.e., "twelve," and ἕδρα, i.e., "face") in Tongeren, Belgium (see [8]). However, the mathematical tourist can visit many more such objects in museums spread all over Europe (see Figs. 1, 2, and 3). Sometimes, the artifacts have even been a source of inspiration for monuments, such as in Homburg a. d. Saar, Germany (see Fig. 4).

It all started on 28 June 1739, when one Mr. North reported to the Society of Antiquaries in London that a remarkable object had been discovered together with some antique coins in Aston, Hertfordshire, England, namely "a piece of mixed metal […] consisting of 12 sides, with an equal number of perforations within them […]" [10]. More than 270 years have passed, and since then 116 similar objects have been unearthed. One of the most recent specimens was found in an archaeological excavation at Cléry-sur-Somme, France, in a refuse pit from the third century CE.

During the past few centuries some two hundred scientists have come under the spell of these objects, among them Count Léopold Hugo, a nephew of the writer Victor Hugo and a pioneer in dodecahedron research, as well as Julien de Saint-Venant [3], Robert Nouwen [11], and Bernhard A. Greiner [4], who all wrote extensive treatises about Gallo-Roman dodecahedra. Even such mathematicians as Moritz Cantor (1829–1920), Ferdinand von Lindemann (1852–1939), and, most recently, Benno Artmann (1933–2010) found them an interesting topic for research (see [1] and [2]).

Some Facts

A Gallo-Roman dodecahedron is a hollow object cast of a copper alloy, and its basic shape—twelve pentagonal faces, twenty vertices, and thirty edges of equal length—corresponds to that of a regular dodecahedron. Knobs of varying appearances and sizes surmount the vertices. Each pentagonal face has a circular hole at the center; the diameters of these twelve holes vary, with the diameters of the smallest holes of a dodecahedron ranging between 6 and 28 mm and those of the largest holes ranging between 17 and 40 mm (see Fig. 5). The height of these dodecahedra is between 40 and 100 mm (measured from face to face, not taking into account the knobs on the vertices), and they weigh between 35 and 580 grams (with one notable exception weighing over 1000 grams). Most of these dodecahedra bear designs on the surfaces (circles around the holes, small circles with dot, lines parallel to the edges, etc.), but no letters, numbers, or similar characters.

Gallo-Roman dodecahedra date back to the second/third century and the fourth century CE. Specimens were found in Austria, Belgium, France, Germany, Great Britain, Hungary, Luxembourg, the Netherlands, and Switzerland. Remarkably,
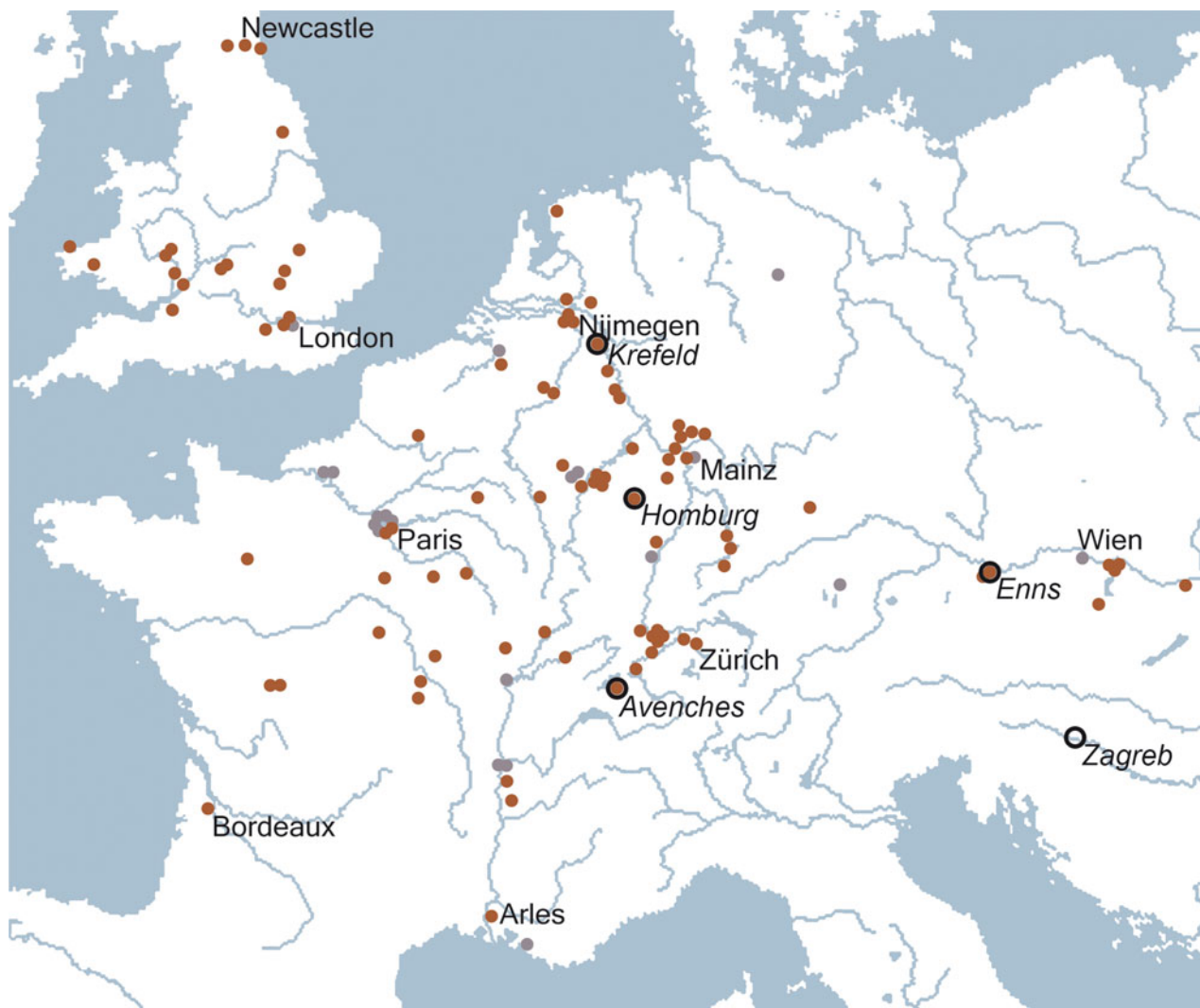
Figure 1. Distribution map of Gallo-Roman dodecahedra (*orange dots*). In some cases only the location of the repository is known (*grey dots*); *black circles* refer to illustrations given in the present paper (map by M. Guggenberger).

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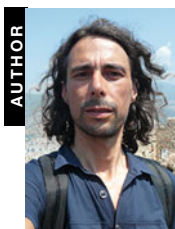
AUTHOR

MICHAEL GUGGENBERGER studied classical archaeology and history at the universities of Vienna and Innsbruck and works at the museum and archive of the Austrian Alpine Club. For him, Gallo-Roman dodecahedra embody a special fascination at the heart of research: the lure of the unknown and mysterious. In addition, he is a disc jockey specializing in obscure music from the 1960s and likes strategic board games, which he plays with his big family.

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none were discovered in the Roman heartland, Italy. The northernmost finding place is Hadrian's Wall in Northern England, the southernmost Arles in southern France, the westernmost Fishguard in Wales, the easternmost the Roman town Brigetio in Pannonia, Hungary (see Fig. 1).

The true aesthetics of a Gallo-Roman dodecahedron lie in its basic geometric shape, which is found in nature, in almost regular form, in pyrite (FeS_2; see Fig. 6; pyrite dodecahedra can be seen in many natural science museums). Plato (approximately 428-348 BCE) had Socrates say in one of his dialogues that the beauty of geometric shapes is not relative but that they are "absolutely beautiful," by nature (Plato, Philebus, 51c-d; see [7]).

In the Pythagorean/Platonic symbolism, the four other regular polyhedrons were associated with the four elements (tetrahedron = fire, octahedron = air, icosahedron = water, hexahedron = earth), whereas the dodecahedron served as an all-encompassing symbol representing the universe: "And seeing that there still remained one other compound figure, the fifth, God used it up for the Universe in his decoration thereof" (Plato, Timaeus, 55c). In the days of the Roman
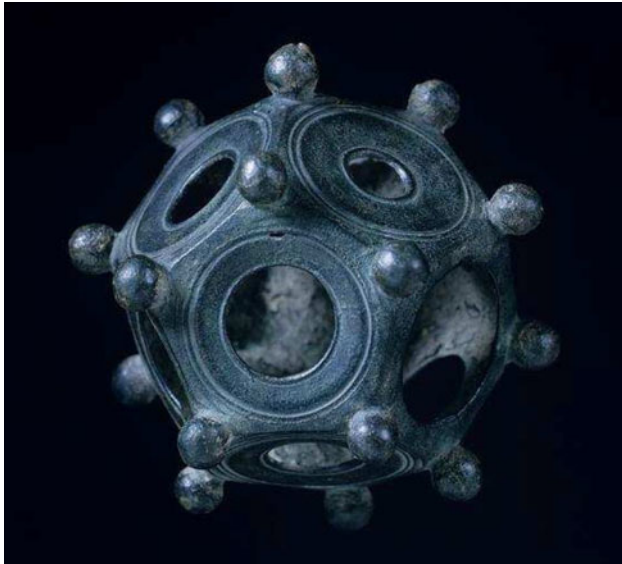
Figure 2. Dodecahedron of Avenches, Switzerland. This nice specimen represents the most common type with circles around ten of the twelve holes, height including knobs approximately 68 mm (inv. no. 1882/1936, photo: Aventicum—Site et Musée d'Avenches, used with permission).

Figure 4. Dodecahedron Monument in Homburg a. d. Saar, Germany (photo: Kolling/LoKiLeCh, Wikimedia Commons, used with permission, Commons).

Figure 3. Dodecahedron of Hof, Austria, showing small circles with dot and circles around the holes, height including knobs approximately 97 mm (Archaeological Museum in Zagreb, photo: I. Krajcar, used with permission).

Empire the philosophic doctrines experienced a revival in the light of a general return to traditional values. One of the advocates of this school of thought was Plutarch (approximately 45–120 CE), who wrote: "The nature of the dodecahedron, which is comprehensive enough to include the other figures, may well seem to be a model with reference to all corporeal being." (Plutarchus, De Defectu Oraculorum, 34).

Another explanation of the Platonic doctrine of the dodecahedron was offered by Alcinous (second century CE): "The dodecahedron God utilized for the universe as a whole, because one sees in the heavens twelve zodiacal signs in the zodiacal circle, and each of them is divided into thirty degrees, even as the dodecahedron is composed of twelve pentagons each divided into five triangles, of which each in turn is composed of six triangles, so that one finds in the dodecahedron as a whole three hundred and sixty triangles, which is the same number as the degrees of the zodiac" (Alcinous, Didaskalikos, H 168,40–169,4). Stobaeus (pres. early fifth century CE) quotes a reference to the "fifth solid" as the "vessel" of the sphere, i.e., figuratively as the "supporting framework of the universe" (Stobaeus, Extracts 1).

Because all specimens of our dodecahedra date from the Roman era but were mostly found in the northwestern provinces of the Roman Empire, with a focus in Gaul, that is, regions strongly influenced by Celtic traditions, we regard them as products of Gallo-Roman origin. Apparently they derived from an environment characterized by the mutual influence of the Roman and Celtic cultures. The decisive impulse is likely to have originated from the Romans after the occupation, given that the regular dodecahedron, as a geometric figure, is known to have played an important role in ancient Greek and Roman cultures for many centuries, whereas there is no evidence of any comparable tradition in the Celtic world.
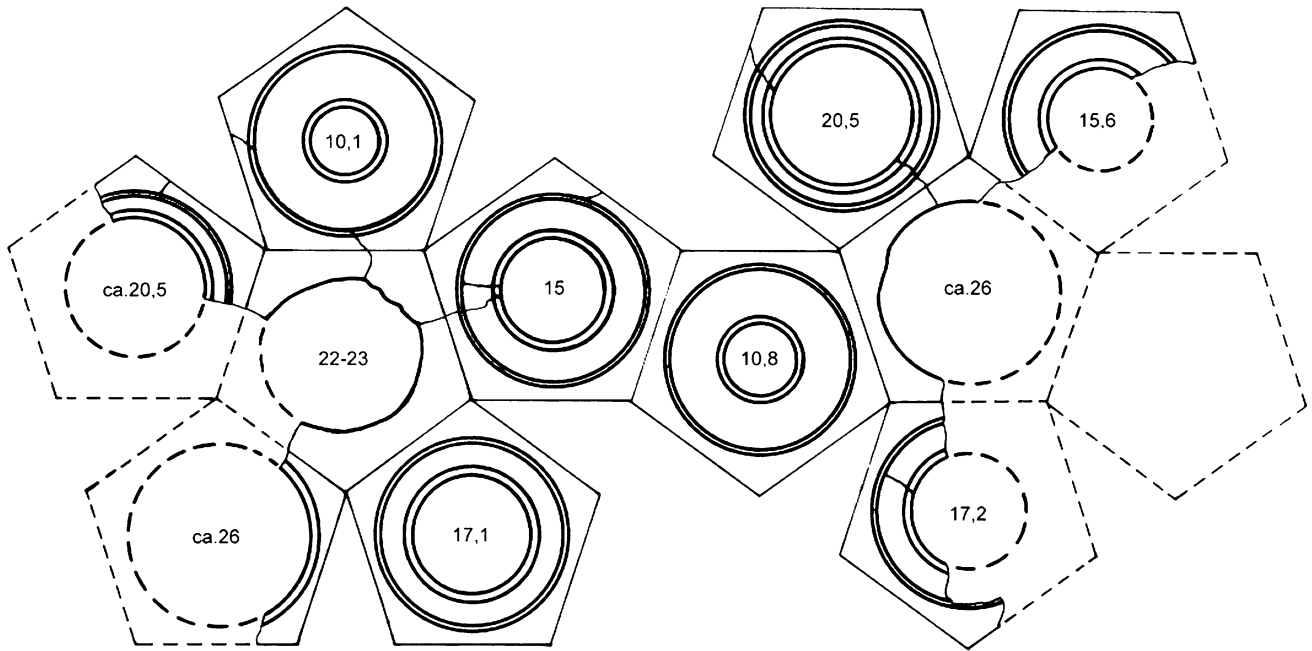
Figure 5. Surfaces and holes of the "Enns 1" dodecahedron (Museum Lauriacum in Enns, Austria), including one undecorated pair of holes with irregular outlines (measurements and design: M. Guggenberger [6]).


Figure 6. Natural pyrite dodecahedron from the Isle of Elba (photo: M. Guggenberger).

Some Speculations

As to the intended purpose of these objects, nearly fifty different theories have been published in the scientific literature; some of them brilliant, some fantastic, and some downright absurd. During the past few decades hobby researchers and esoteric circles have become increasingly interested in Gallo-Roman dodecahedra and have come up with a virtually infinite number of further interpretations. Two comprehensive surveys summarize different theories (see [11] and [5]). Suggestions that it was used as a weapon nowadays merely meet with mild amusement. The possibility that it was some sort of measuring device (rangefinder, calibration gauge, astronomical measuring device, etc.) is currently more "fashionable" [9]. Or perhaps they were purely decorative items, a craftsman's masterpiece or a mere toy, or an extravagant household item used as a kind of light container
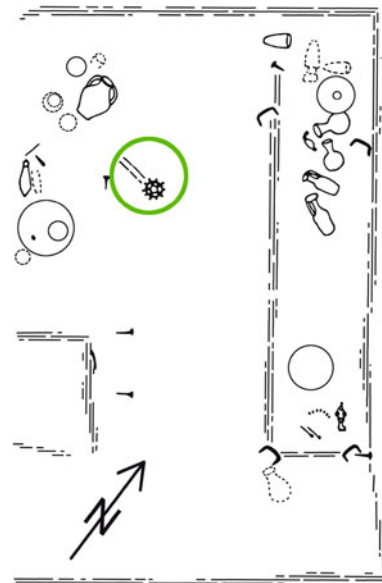
Figure 7. Position of the dodecahedron (*green circle*) in the richly equipped tomb of a woman in Krefeld-Gellep, Germany, immediately adjacent to an object of bone (diameter approximately 30 mm, length approximately 150 mm), which could have served as a kind of handle (design: M. Guggenberger according to R. Pirling: Die Fränkischen Altertümer des Rheinlandes 13 (1989) table 153).

(thus enhancing its cosmic symbolism), or a sign, an insignia, or instrument of cosmic power.

Based on the number of finds, the quality of the materials, and the costly manufacturing process, it is evident that these dodecahedra were neither bargain goods that could be bought on every corner, nor were they extremely rare objects. Yet, the complete absence of contemporary written sources or images describing or depicting Gallo-Roman dodecahedra may imply that their purpose was of a secret nature. That most of the finds don't come from well-documented excavations adds further complication. But the position in which a dodecahedron was discovered in the richly equipped tomb of a wealthy woman from the middle of the fourth century in Krefeld-Gellep, Germany, suggests a connection with a staff or handle made of bone. Regrettably the bone object was too badly preserved to be salvaged, so that today only a drawing exists (see Fig. 7) [12]. It can only be hoped the conditions in which Gallo-Roman dodecahedra were found will be examined more carefully in the future, so that mathematicians can, perhaps, finally find out what a dodecahedron was good for, 2000 years ago.

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