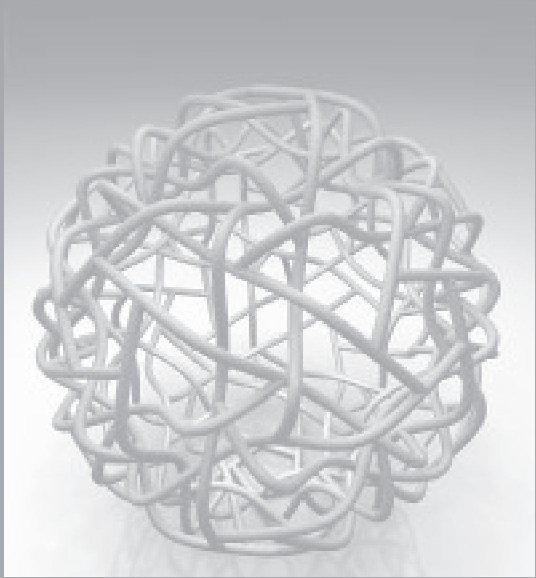
RINUS ROELOFS



STRUCTURELE SENSATIE

Expositie in het kader van

QUA ART | QUA SCIENCE

februari - april 2005 | Faculty Club Universiteit Twente

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Beeld & Aambeeld

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STRUCTURELE SENSATIE

De emotie van een digitale beeldhouwer
of
een bijzondere manier van ruimtelijk denken.

Het proces van de kunstenaar Rinus Roelofs begint bij denkbeelden. Bij beelden die in zijn hoofd ontstaan. Hij noemt zichzelf een digitale beeldhouwer en hij gebruikt zijn computer als een driedimensionaal schetsboek.

Zijn ervaringen doet hij al doende op, werkend aan structuur.

De computer wordt een verlengstuk van zijn denken, hij kan er ideeën op uitwerken.

“Alles wat denkbaar is, is maakbaar. Wanneer ik een idee heb, dan kan ik dat binnen een kwartier als beeld virtueel uitwerken op de monitor.”

De virtuele wereld speelt een grote rol in de ontwikkeling van zijn denkbeelden. Vooral omdat je onmiddellijk kunt reageren op een beeld. Alles wat op de computer staat is al een werktekening, er is dan al van alles uitgezocht.

Zijn hoofdonderwerp is structuur, hij denkt niet meer in materiaal, maar in een object. Wanneer hij beslist om zijn denkbeeld te materialiseren kan hij altijd nog kiezen voor brons, zilver, textiel of wat dan ook. Alle klassieke vaktechnieken zijn daarvoor bruikbaar. Op die manier ontwikkelt hij ook een andere, verfrissende kijk op kunstproductie omdat hij daar eigenlijk niet zo mee bezig is. Het gaat bij hem vooral over ideeën en daar houdt het soms mee op.

In de wiskunde is alles wat je plat duwt, een vlak. Wanneer lagen (vlakken) over elkaar liggen ontstaan driedimensionale constructies.

Het heeft Rinus Roelofs altijd geboeid om iets te maken wat niet meer plat te drukken is. Een soort gekte, overgehouden van zijn wiskundestudie. De stap van twee- naar driedimensionaal, dat wil hij in constructies laten zien. Hoe je structuren door elkaar heen kunt weven die elkaar niet in de weg zitten, dezelfde ruimte innemen.

Zowel in de kunst als in de wiskunde maak je afbeeldingen. Hij probeert manieren te verzinnen en vanuit zijn wiskundige achtergrond komt hij uit bij bijvoorbeeld een duaal van een vorm. Dualiteit immers is ook een vorm van afbeelden en met dat begrip gaat hij aan de slag en creëert bijna als vanzelf andere vormen.

Op dat moment wordt het hele proces een bijzondere manier van ruimtelijk denken en voor Roelofs gaat het dan echt over beelden.

En of die beelden uiteindelijk wel of niet te materialiseren zijn dat doet er eigenlijk niet toe. Ze zijn toch te tonen.

Structuur en de sensatie daarvan spelen een grote rol. Hoe je structuren in beweging kunt zetten en die beweging dan als materiaal te gebruiken.

Zijn vakgebied is misschien nog klein, maar door internet kan hij bij heel veel anderen kijken. Hij zoekt eindeloos op internet met steekwoorden als wiskunde, structuur, art en science. Bouwt op die manier aan zijn gedachte bibliotheek en vindt zijn kompanen.

Interessante collega's, zoals Kim Williams en George Hart, een professor wiskunde en kunstenaar. Samen met Hart maakt hij nu een beeld, ongelooflijk interessant. Zo heeft hij Kenneth Snelson leren kennen die de 'Needle Tower' heeft gemaakt voor Kröller Müller. Ook met hem deelt hij zijn passie. En sinds een aantal jaren neemt hij deel aan de 'Bridges-Conference', een voor hem geweldig stimulerende uitwisseling en ontmoeting met kunstenaars en wetenschappers van overal. Steeds op een inspirerende plek in een ander land.

"Werken via zo'n medium lijkt misschien berekenend en afstandelijk,
maar je komt juist vaak erg dicht bij anderen.
Bij een wiskundige bewijsvoering of bij het zoeken naar interessante structuren kan ik
heel wat emotie ervaren, helemaal als je nieuwe mogelijkheden vindt. Je ervaart dat pas als je
er mee bezig bent welke rol structurele sensatie speelt. Dat is zoiets overweldigends, je wilt dolgraag
dat mensen dat gaan herkennen."

Martha J. Haveman, Enschede, februari 2005

STRUCTURAL SENSATION

The emotion of a digital sculptor
or
a particular way of thinking in three dimensions.

The process of artist Rinus Roelofs starts with ideas. Sculptures that have taken shape in his head. He calls himself a digital sculptor using his computer as a three-dimensional sketchbook. He gains his experiences as he goes along, working on structure. The computer becomes an extension of his thinking – he uses it to develop his ideas.

"Anything that can be conceived, can be made. When I have an idea I can develop it into a virtual image on the monitor within fifteen minutes".

The virtual world plays an important role in the development of his ideas, especially because an image may call up an immediate reaction. Everything that is on the computer is already a technical drawing, all kinds of things have already been sorted out.

His main subject is structure, he no longer thinks in terms of materials, but in terms of an object. The choice of bronze, silver, textile or whatever need not be made until the moment he decides to materialize his idea. All traditional techniques may serve this purpose. In this way he also develops a different, refreshing perspective on artistic production, because he is not really concerned with it. He is mainly interested in ideas and sometimes that is where it ends.

In mathematics anything flattened is a plane – layers (planes) lying every which way will form three-dimensional constructions.

Rinus Roelofs has always been fascinated by the thought of making something that can no longer be flattened, some crazy idea dating from the time he studied mathematics. The step from two to three-dimensional, that is what he wants to show in his constructions. How structures, not standing in one another's way but occupying the same space, can be interwoven.

In art as well as in mathematics you make images. He tries to find new ways and with his mathematical background may arrive at e.g. a dual image of a shape. For duality is also a form of transformation, and using this notion he gets to work creating different shapes almost as a matter of course. At that moment the whole process becomes a particular way of three-dimensional thinking and as far as Roelofs is concerned we are really dealing with sculptures here.
And whether or not these three-dimensional objects can ultimately be materialized is irrelevant; they can be shown.

Structure and its sensation play an important role: How to put structures in motion and then use that motion as material.

His speciality may as yet be of limited scope, but the internet enables him to look at what many others are doing. He is forever surfing the internet using keywords like mathematics, structure, art and science.

In doing so he builds up his library of thoughts and finds his buddies – interesting colleagues like Kim Williams and George Hart, a professor of mathematics and artist. With Hart he is now working on a joint sculpture, incredibly interesting. In this way he also got to know Kenneth Snelson who made the 'Needle Tower' for Kröller-Müller and who shares his passion. And since a number of years he has taken part in the 'Bridges Conference', an exchange which provides him with a tremendous stimulus and an opportunity of meeting artists and scientists from all over the world, every time in an inspiring spot in a different country.

"Working through such a medium may seem calculating and detached, but it often brings you very close to others. In the course of a mathematical demonstration or when searching for structures I can experience quite some emotion, especially when I discover new possibilities. Not until you are working with it do you realize the role of structural sensation. It is something so overwhelming that you would like nothing better than for other people to recognize it."

Martha J. Haveman, Enschede, February 2005

In 1989, I began constructing domes using notched bars assembled according to a simple rule. This led me to explore planar constructions based on this rule using fixed length 'notched' line segments. I was able to create a wide variety of patterns. Based on certain of these patterns I was able to construct spheres and cylinders from notched curved rods without the use of glue, rope, nails, or screws. Surprisingly, drawings found in the notebooks of Leonardo da Vinci suggest that he too explored constructions based on this simple rule.

The construction admits a simple description. On each rod we determine four points as indicated in figure 1. We call these points connecting points. We distinguish two types of connecting points: End points (closest to the ends of the rods and interior points (the remaining points). So each rod has two end points and two interior points.

Figure 1: Position of the four connecting points

In constructing the dome we apply the following rules: one of the endpoints of a rod is placed on a free interior point of a different rod. At the end all connecting points of the rods have to be used as a connection between two rods, except near the border of the construction.

Now the actual construction of the dome turns out to be a simple task. Beginning with four rods as in figure 2 we extend the construction by continually adding rods at the bottom (see figure 3). Since we add one rod at the time, on the outer edge, the dome can be constructed by one person. The four poles with which we have started will rise automatically during the building process and at the end the dome, consisting of 64 rods rests on the earth with only 16 rods (see figure 4).

With the above construction process various patterns can be formed, each leading to a domelike construction. In the sequel we will call the patterns that can be formed with the above rules bar grids. The bar grid of the dome of figure 4 can be drawn simplified as in figure 5. In this form the drawing looks like a tiling pattern. However, we are not interested in the tiles but in the joints between the tiles. So we have a grid consisting of straight lines representing the rods. A first investigation into the various possible bar grids soon resulted into dozens of patterns, some of which are shown in figure 6.

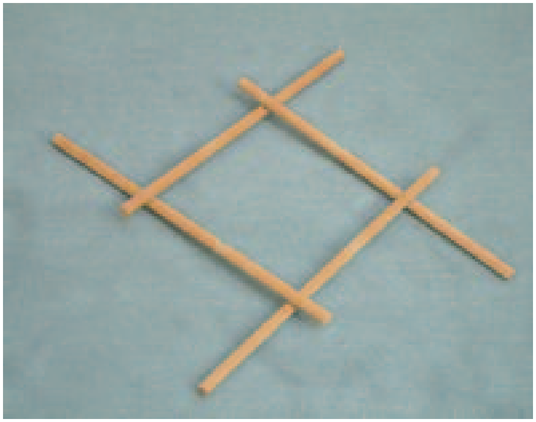


Figure 2: Dome construction

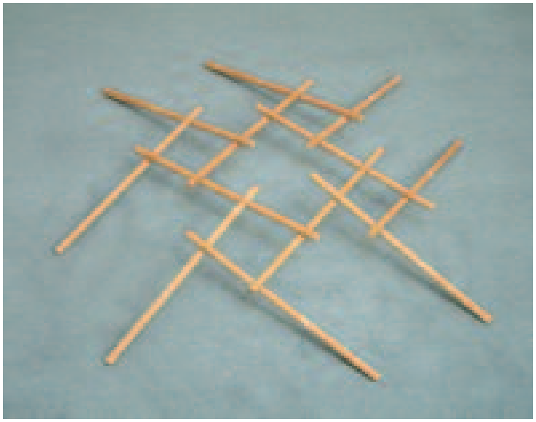


Figure 3: Dome construction

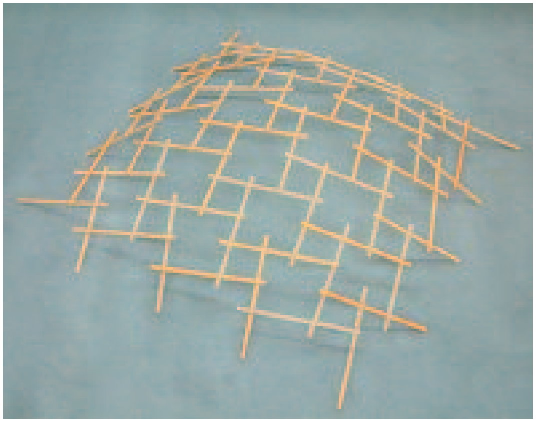


Figure 4: Dome construction

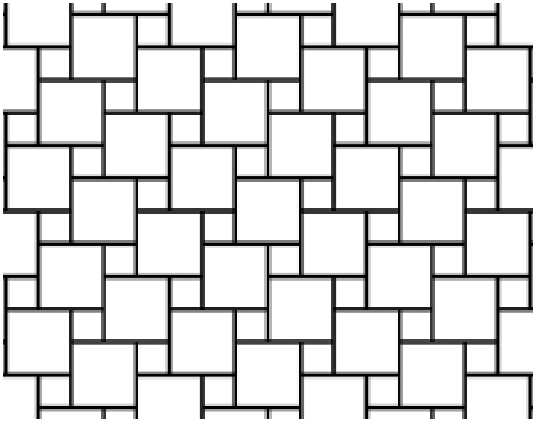


Figure 5: Bar grid

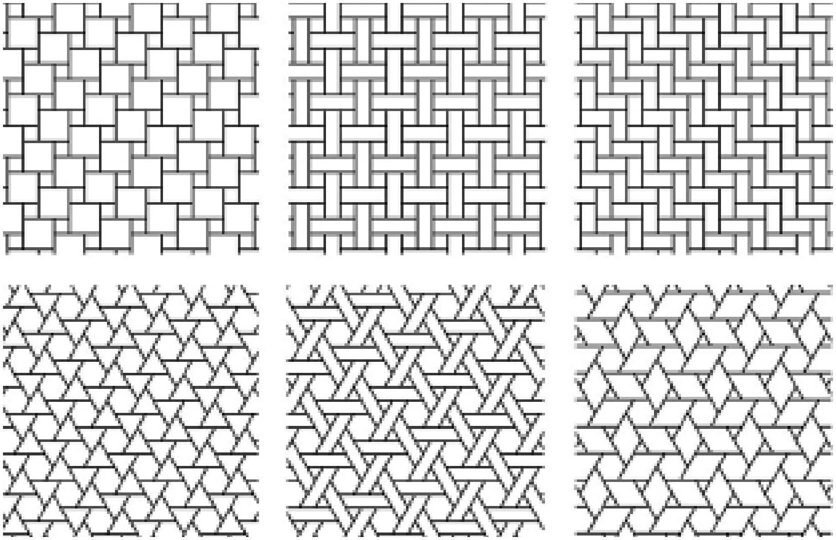


Figure 6: Examples of bar grids

LEONARDO DA VINCI

Since the system is so simple, I could not imagine that it had not been invented before. The first name that came into my mind was Buckminster Fuller. In his work I found related drawings of patterns, however the constructions derived from them are all made from rods and wires (tensegrity). In the end I have found only one comparable source. On a page from one of the notebooks by Leonardo da Vinci, Codex Atlanticus f. 328 v-a, we find among others three patterns with exactly the properties of the bar grids defined above (see figures 7, 8, 9).

A reprint of this page can be found in Carlo Pedretti's book Leonardo Architect[1]. As a description of the contents of this page Carlo Pedretti gives: "Studies of wooden roofing made up of parts that fit together." And in the text it is described as: "Geodesic roofing for vast area of land, anticipating the daring constructions of Buckminster Fuller". In view of the way in which the patterns are drawn, oblong forms that seem to lie on each other, the most direct interpretation is that here we have to do with stacking construction build from straight rods. On making a model this leads exactly to the domes that I found. So the conjecture seems justified that Leonardo da Vinci is the first inventor of these constructions, although we cannot be sure about this.

1 Carlo Pedretti, Leonardo Architect, pp. 154-155 (1981).

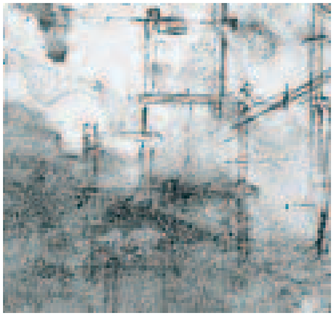


Figure 7: Pattern 1

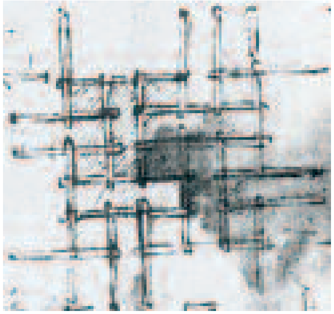


Figure 8: Pattern 2

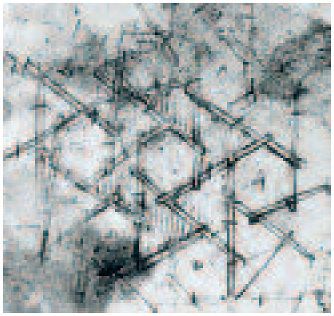


Figure 9: Pattern 3

SPHERES

In the domes it is gravity that keeps the loose rods together. It follows that continuing the construction as far as a complete sphere is not possible. Yet it turns out that using the above construction system objects can be formed where only the elements themselves, instead of gravity, keep the construction together. For example, we can assemble a sphere from a number of rods, or more generally elements, without using connecting materials like wire or glue. The number of connecting points per elements and the connecting rules do not change. It is only the form of the elements that changes. For a sphere we use curved rods instead of the straight rods for a dome.

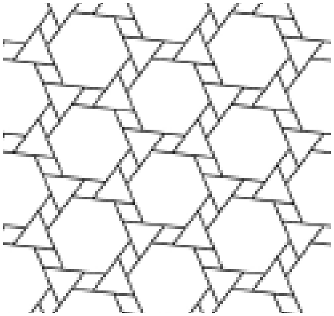


Figure 10: Bar grid

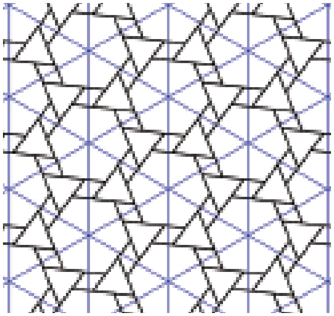


Figure 11

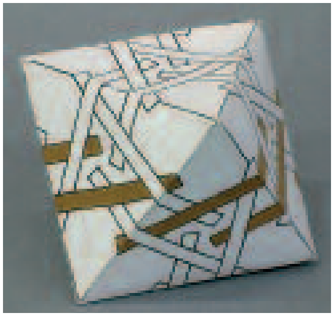


Figure 12: Octahedron

A simple way to come to a design for such a sphere shaped construction is the following: in the bar grid of figure 10 the midpoints of the hexagons are connected such that a pattern of triangles results (figure 11). Eight of these triangles can be used to form an octahedron (figure 12).
On this octahedron we now see a grid consisting of 24 bars and this can be used a design for the sphere of figure 13. The form of the elements has been determined such that no tension arises in the sphere. Only when closing the sphere non-rigidity of the elements is required. The relative position of the elements causes the sphere to stay in one piece: each of the elements is prevented to fall by other elements. For the sphere of figure 14, which consists of 90 elements, the icosahedron has been used as an intermediate step so that pentagons occur in the construction.

Figure 13: Sphere - 24 elements

Figure 14: Sphere - 90 elements

OTHER SHAPES

A real new step was made at the development of objects in which the inner space of the sphere is used too, as in figure 15. This object has the form of two linked concentric spheres. The whole is a stable construction consisting of 24 elements. Each element is halfway (that is to say with two out of four connecting points) in the outer sphere and halfway in the inner sphere. The object of figure 16 is a different example; it is composed of 12 elements. Three of the elements leave the outer surface of the sphere with its middle part leading to an intriguing structure.

In June 2003, there was a seminar held at the Da Vinci Museum at Vinci, Italy to explore the relationship between Leonardo's sketches and the constructions shown. We made some large-scale constructions using notched poles at that time (see figure 17).

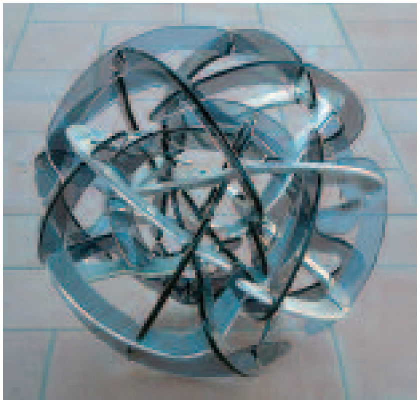


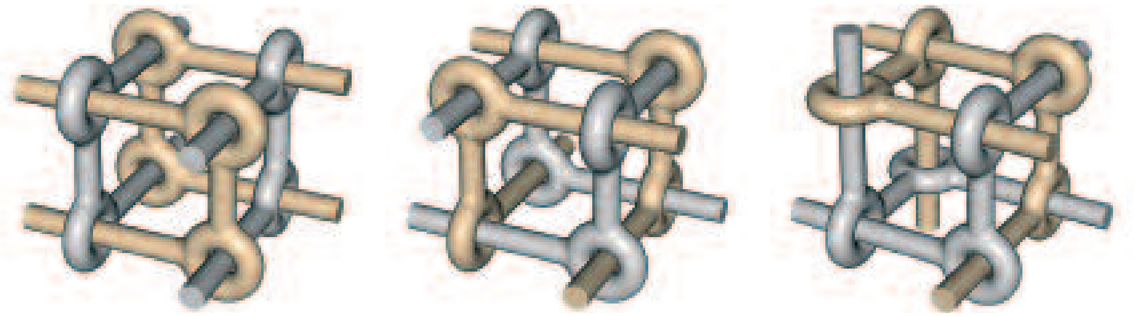
Figure 15: Concentric Spheres


Figure 16: Inside the Sphere

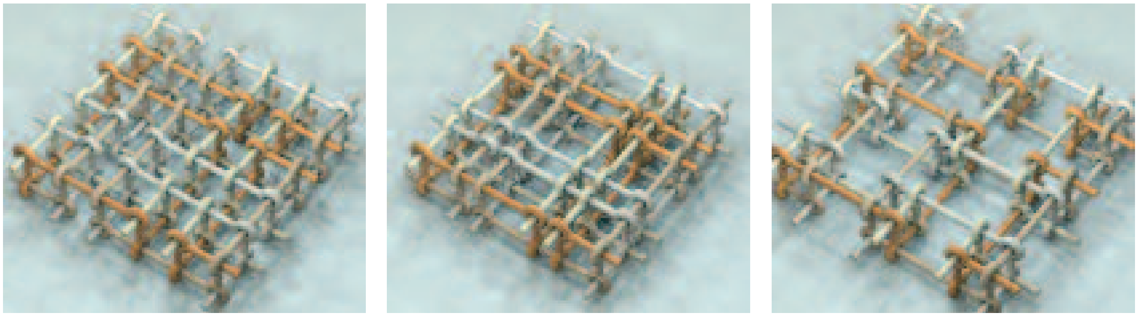

Figure 17: Dome with poles

STRUCTURAL SENSATION

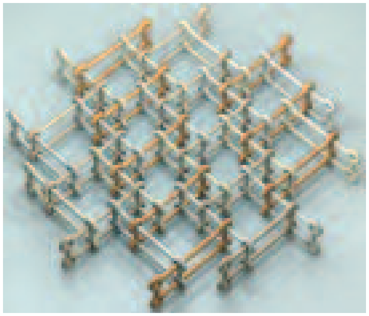
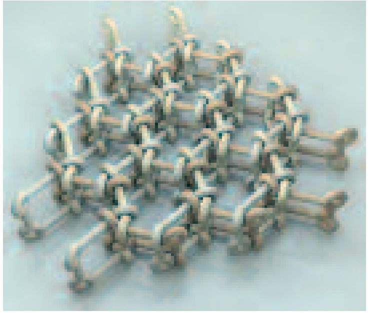
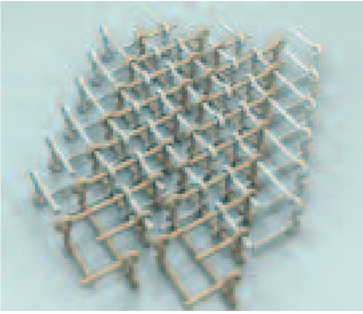
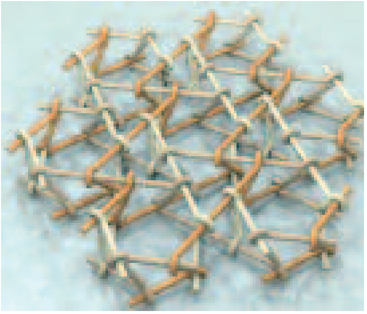
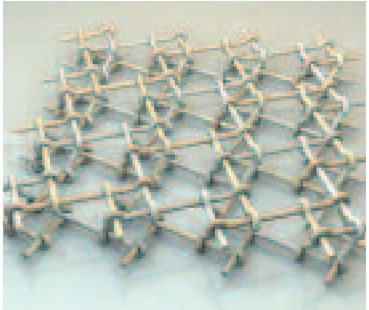
We ended with planar constructions based upon the Leonardo grids. We will now take it on step further towards Leonardo grid space frames I first tried to find a way to construct infinite double layer structures. Space frames can be build by connecting polyhedra in a systematic way. With cubes you can fill the space. And when you look at the graph that represents the cube you will notice that all vertices have degree 3, which was the condition for the Leonardo grids. A cubic frame can be made as a Leonardo grid construction in three different ways.



A way to make a double layer structure is to connect these kinds of cubes. This will result in a non-planar infinite construction that has also dynamic properties. The elements can slide between certain boundaries and the total construction can be pressed together or stretched.

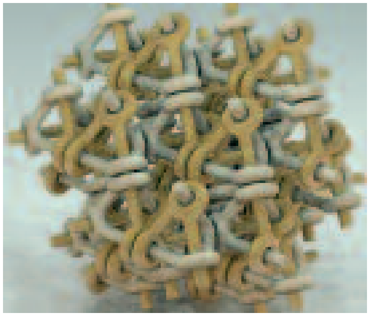


In the double layer structures the basic elements, the rods with the 4 connecting points, are linked together to form bigger units. We can distinguish two kinds of these bigger units: rings, a closed concatenation of a finite number of basic elements, and strings of concatenations of an infinite number of basic elements.

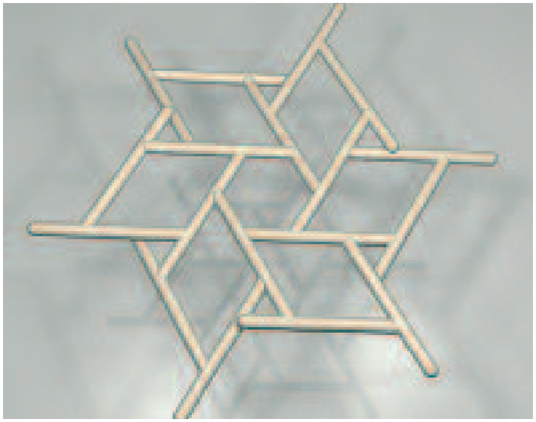







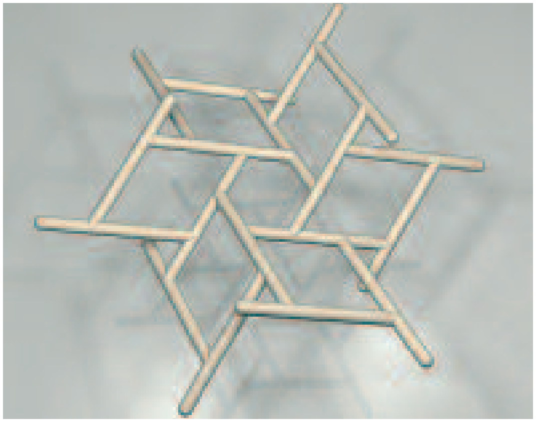
And these constructions don't have to be limited to 2 layers. Here an infinite 3D construction is built with one type of string, which is a concatenation of basic Leonardo grid elements.

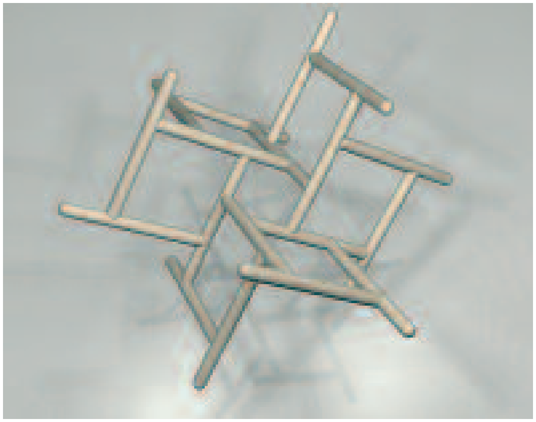




Another and yet maybe even better way to construct real 3D structures based on Leonardo grids appeared to be the use of transformation of the basic Leonardo grid from 2D to 3D. The process can be described as follows: we can start with any pattern in which we can find a hexagonal hole. We now keep the 6 sticks around this hole connected and change the hexagon from flat to skew. This change will cause a transformation of the sticks, which are connected to the first 6 sticks. The six parallellogram shaped holes in the pattern will also be parallellogram shaped at the end of the process. But one of the connections around the triangle holes will get loose. The resulting structure now can be used as a layer with which we can create space frames.





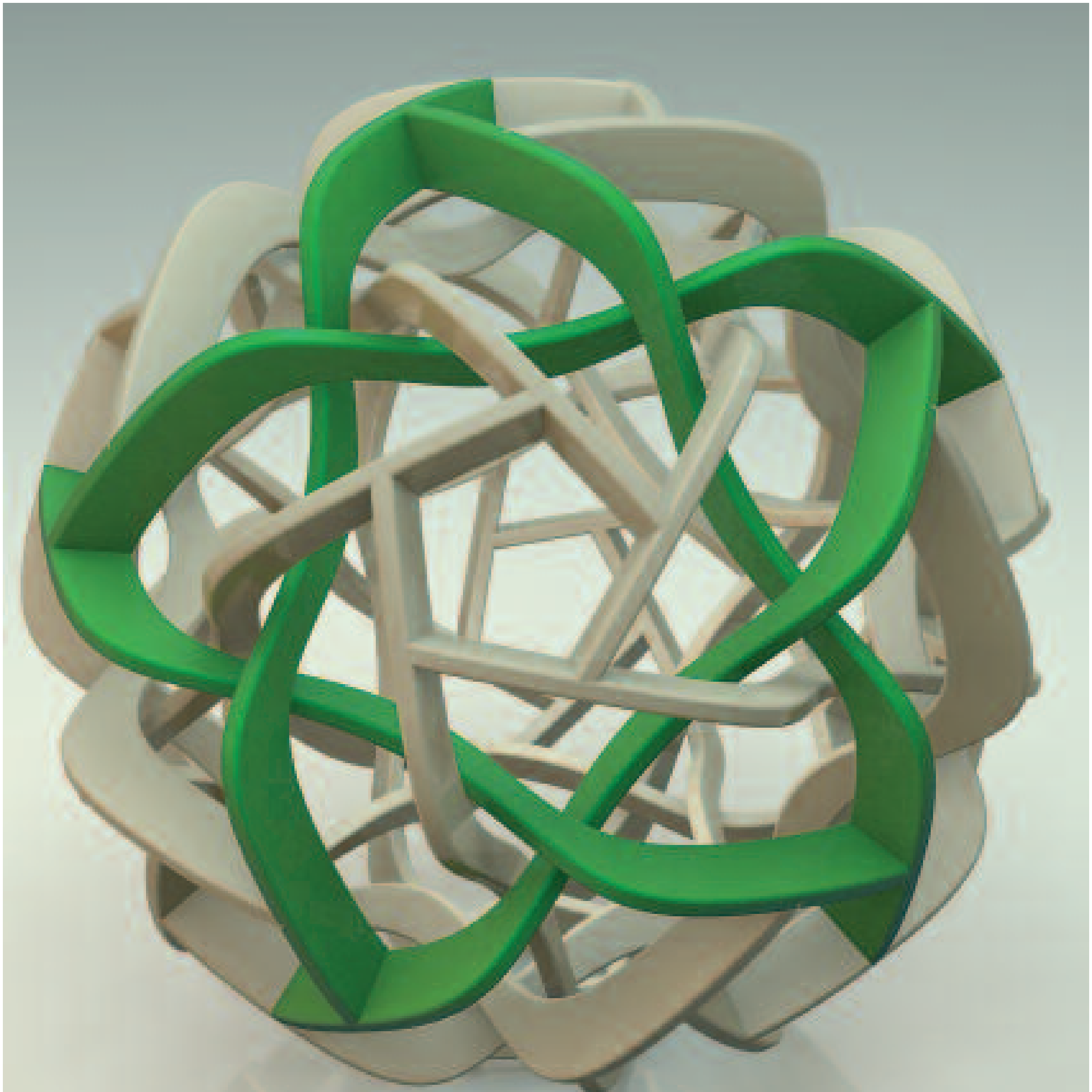


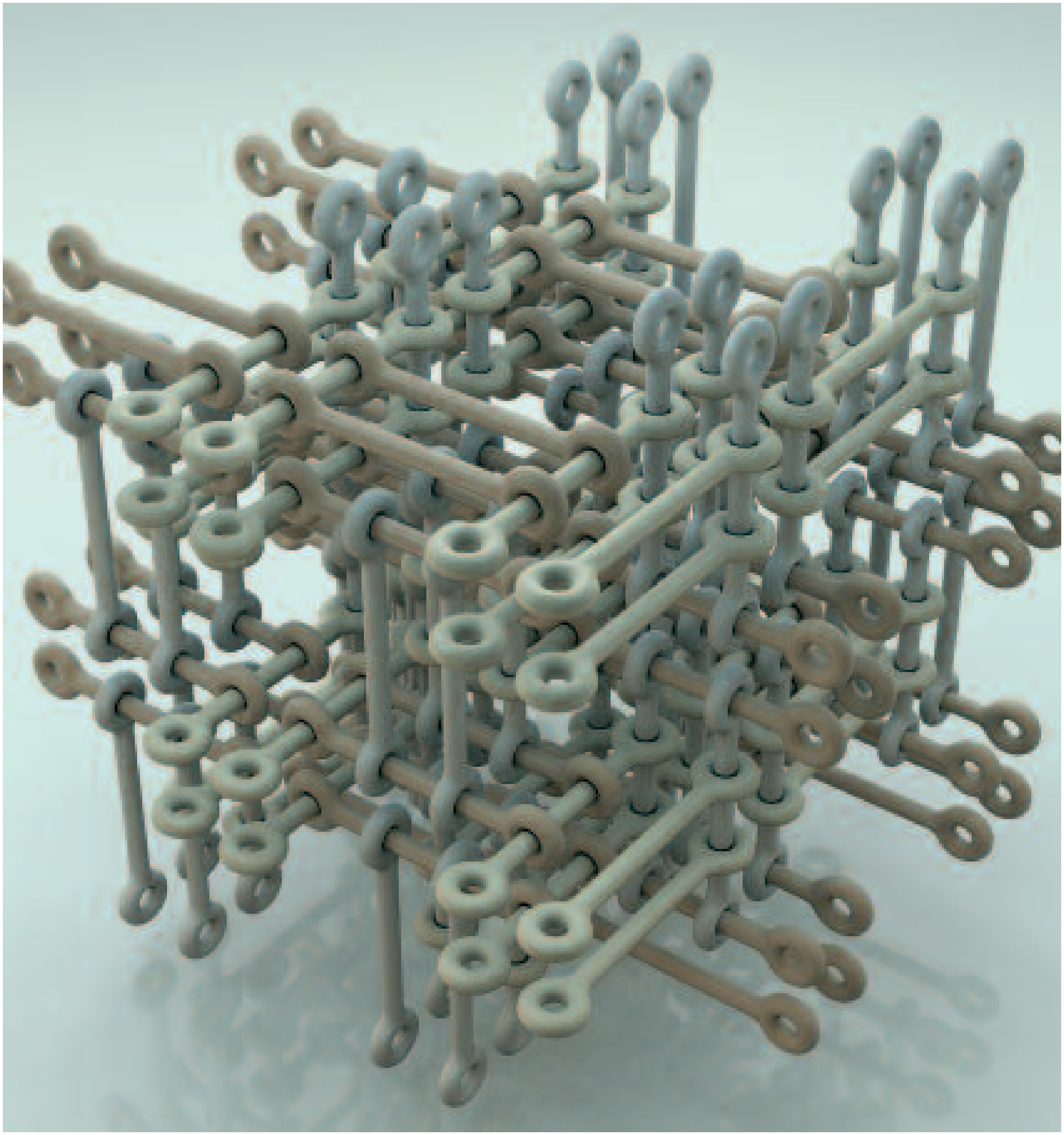
The discovery of this process leads to many designs of Leonardo grid space frames because the process can be applied to all the flat basic patterns. We can also start with a square hole in a pattern. In the same way the flat hexagon is transformed into a skew hexagon, a flat square can be transformed into a skew square. The more than a hundred different patterns that I had drawn as possible designs for the domes can now be transformed to Leonardo grid space frames.

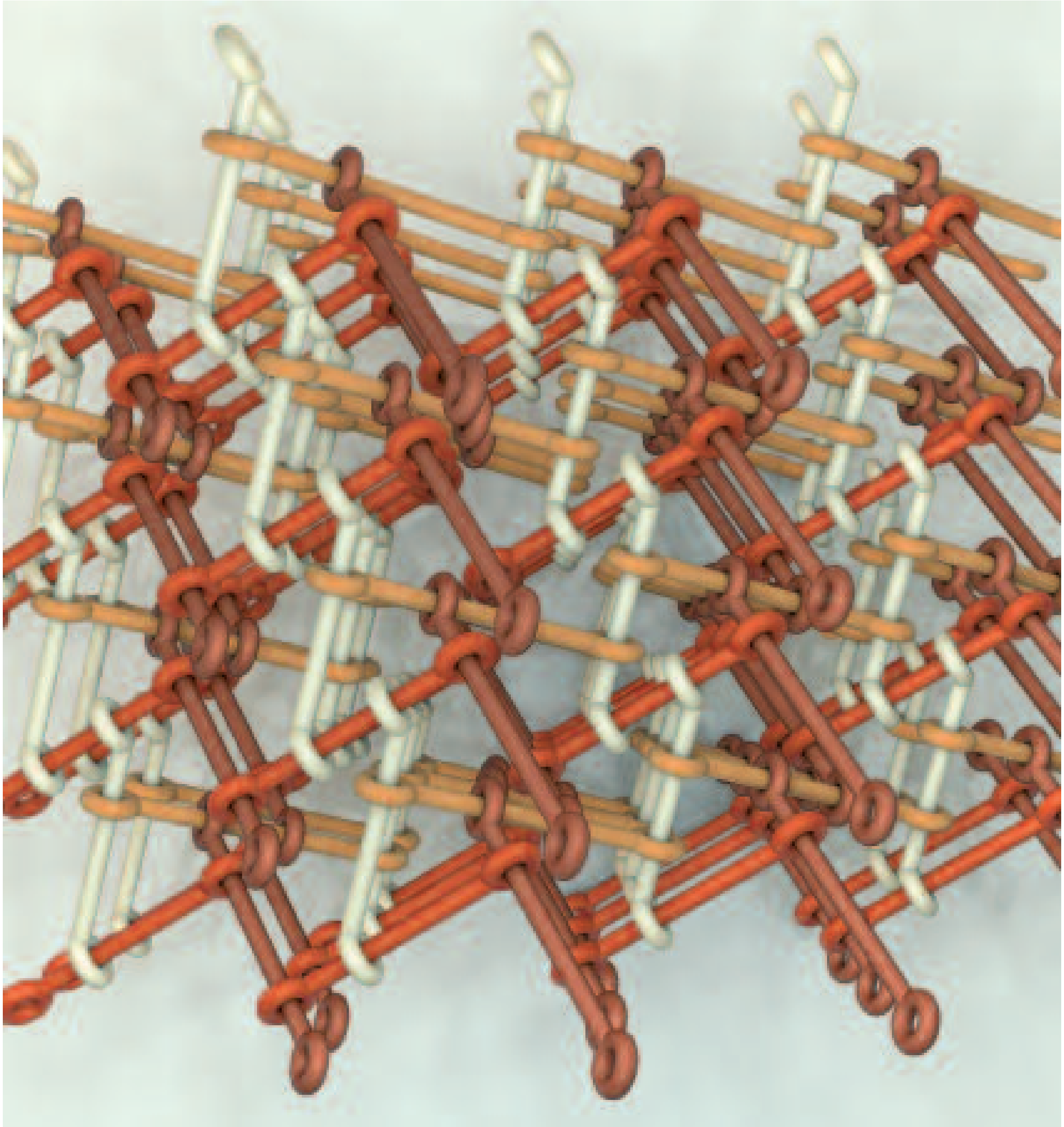
Just like in the double layer structures the Leonardo grid space frames have also got dynamic properties. The sticks can be slided along each other and so the total construction can be pressed together or stretched. To show this we will go back to the skew hexagon first. In the total movement it looks like there is some twist in the structure. In a way the shrinking and growing of the structure is a spiral movement.

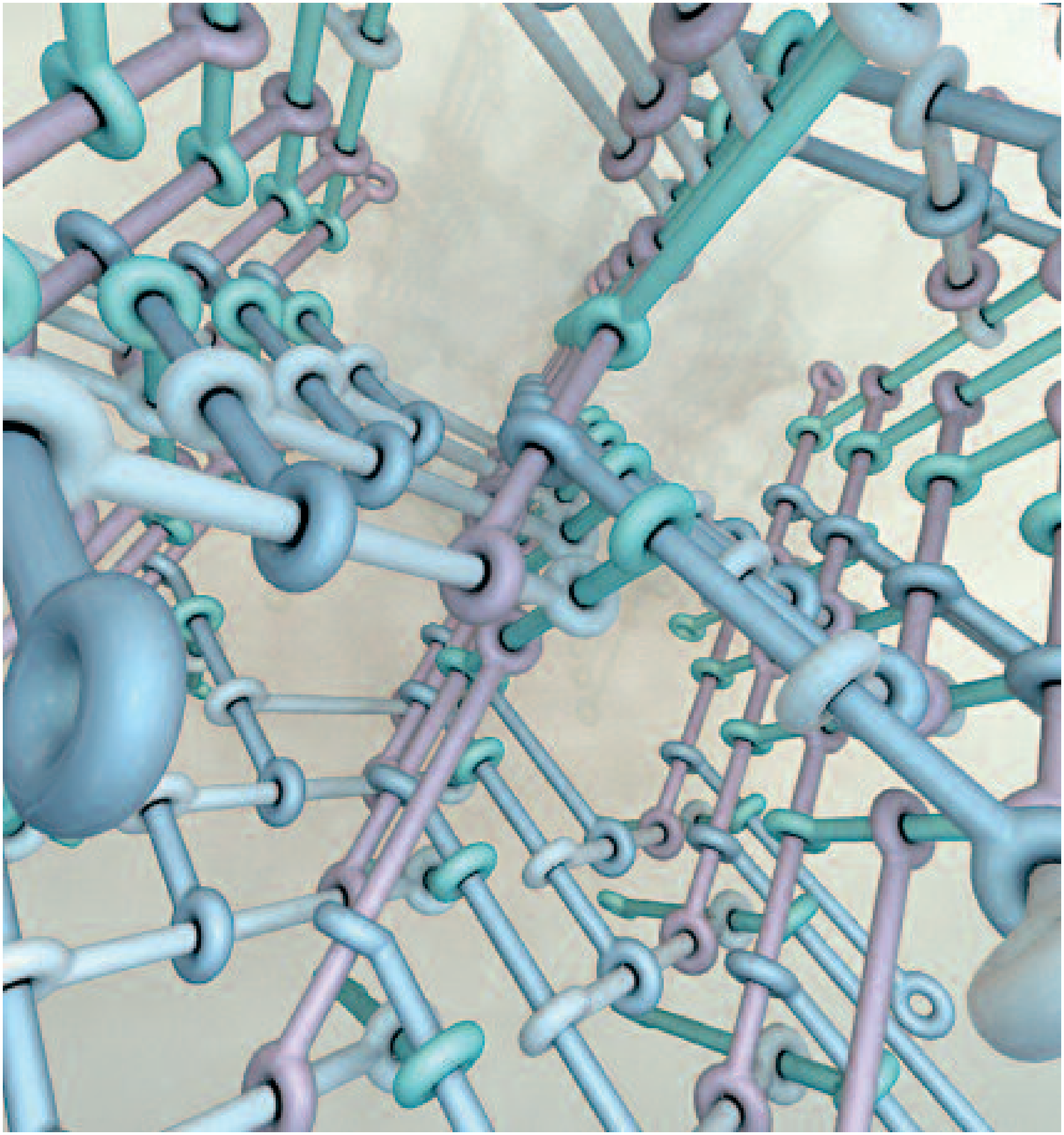
While studying dynamics in the 3D Leonardo grid constructions I also discovered an interesting new way of translating 2D Leonardo grids into dynamic structures. Looking again at the basic grids you have to realize that there are two possible interpretations: you can either look at it as a construction build out of rods or as a tiling, a pattern build with a set of tiles. Then the dividing lines form the Leonardo grid.

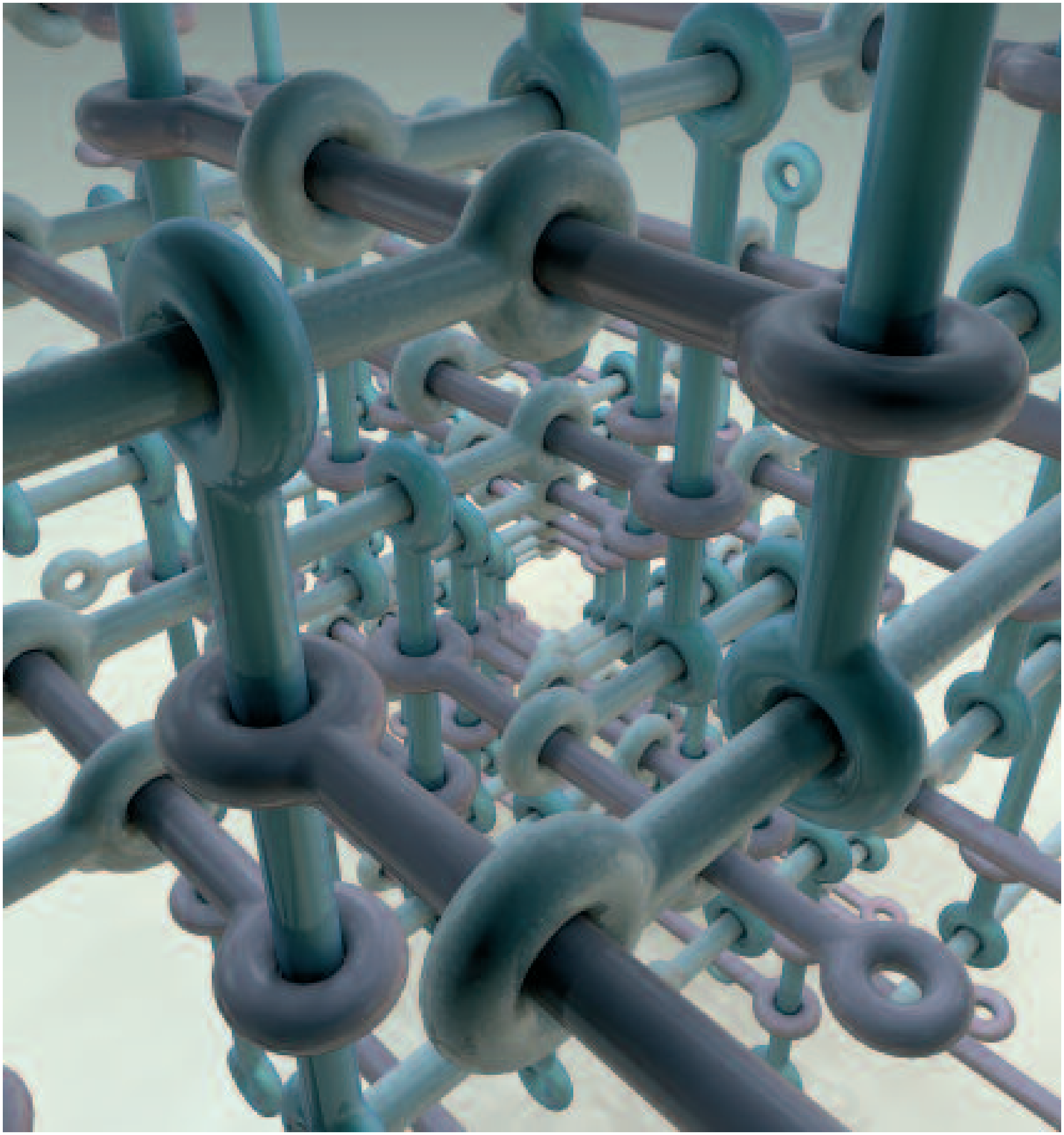
One line in this grid represents the edges of 4 tiles: 2 big tiles and 2 small tiles. So this one gridline can be seen as a set of 4 edges. And because the edges are alternating long-short-long-short, the set of edges can be seen as a parallellogram. In the original grid the tiles are close to each other so the area of the described parallellogram is equal to zero. But what will happen when we ‘open’ the parellallegram? Well then the set of tiles will turn out to be a dynamic hinged construction. The Leonardo grid lines will transform from a line to a parallellogram to a rectangle and via parallellogram to a Leonardo grid line again. And as a result of this process the left-hand orientation of the Leonardo grid has changed into a right-hand orientation. This can be best viewed in animations.

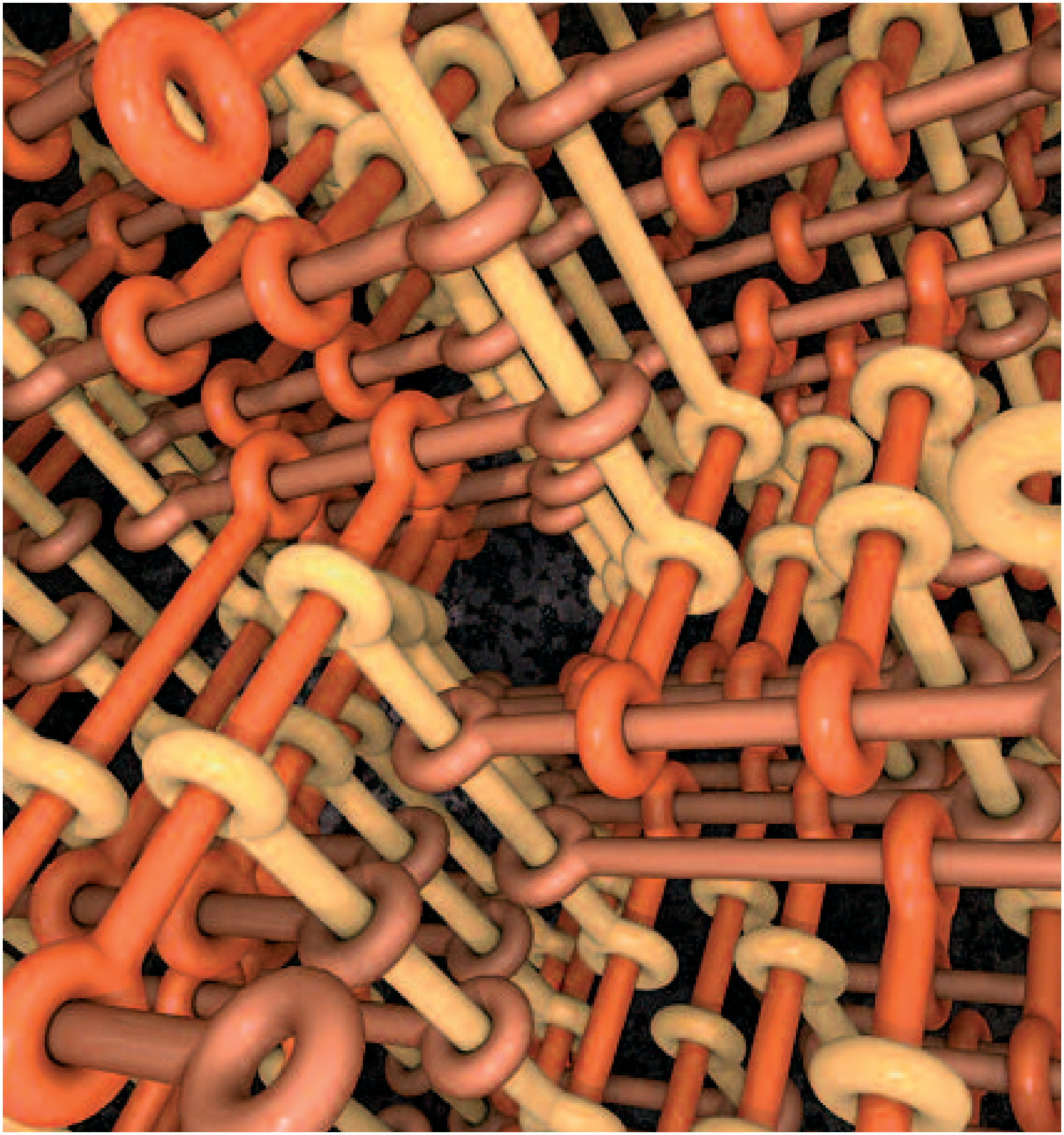


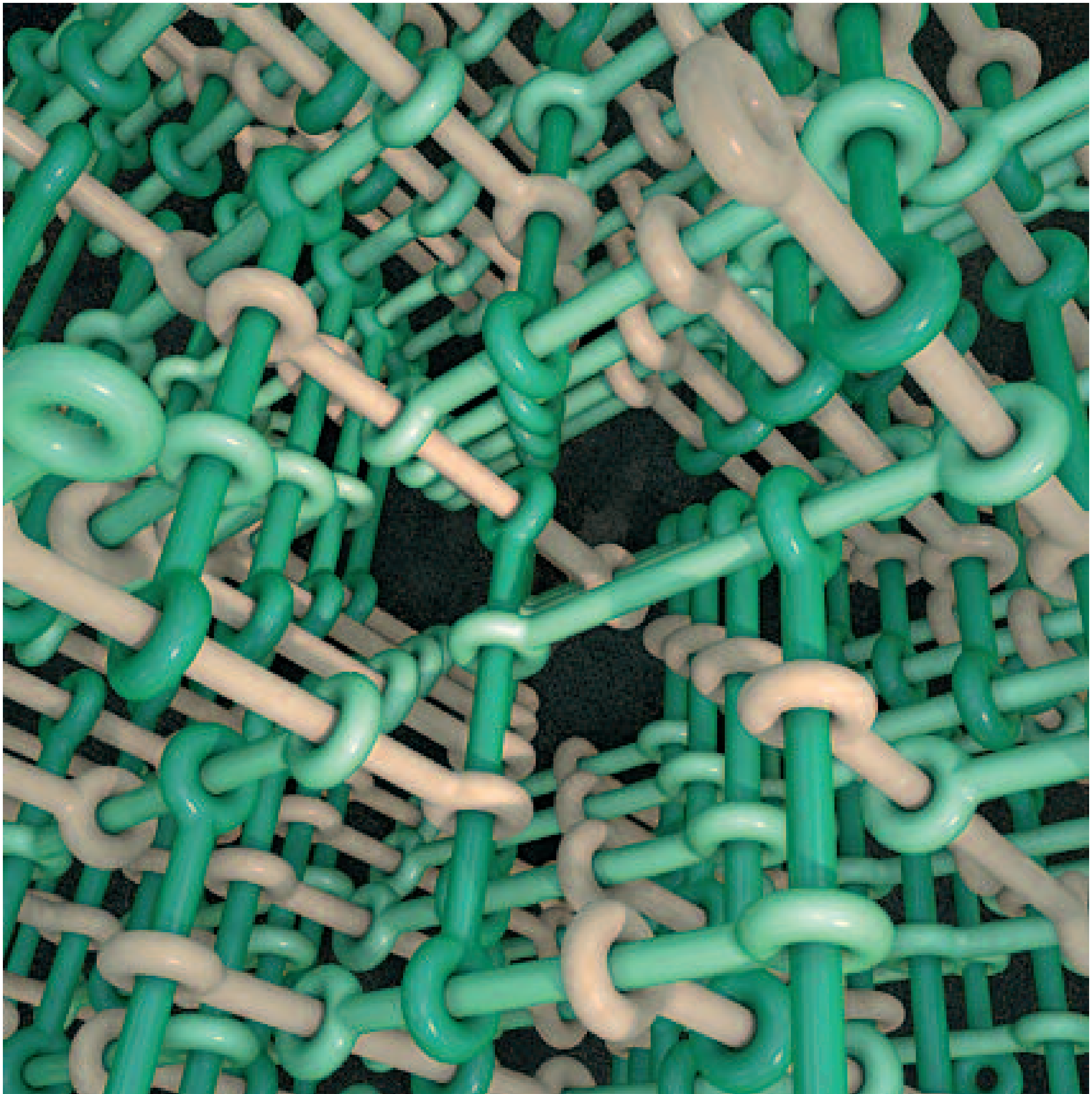


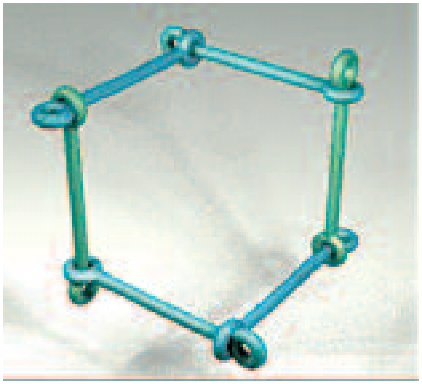
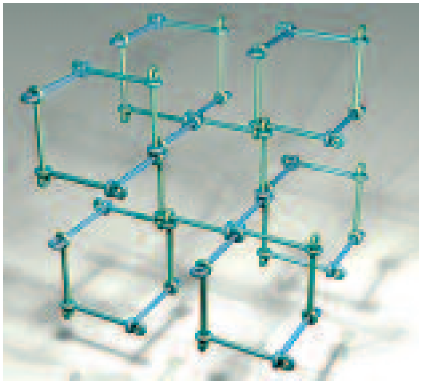
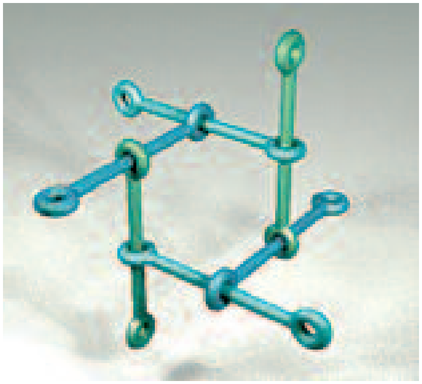
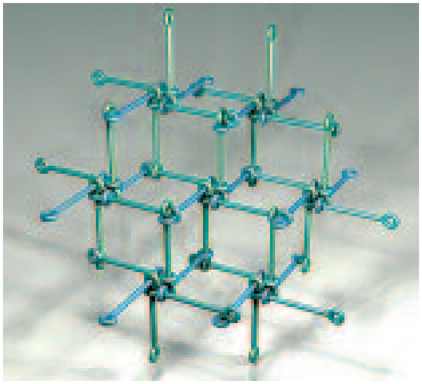
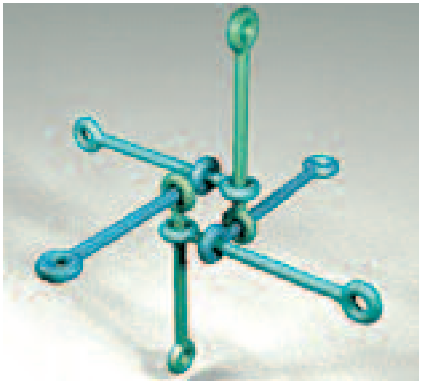
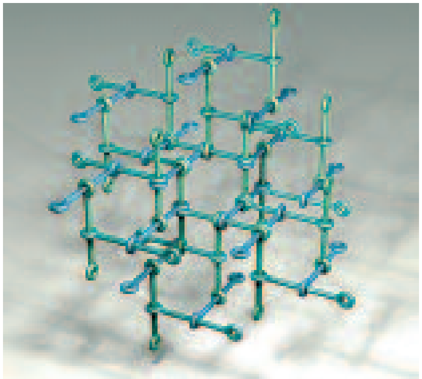










Colofon

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