return to updates

THE MANGANESE-ALUMINUM QUASI-CRYSTAL

a prediction

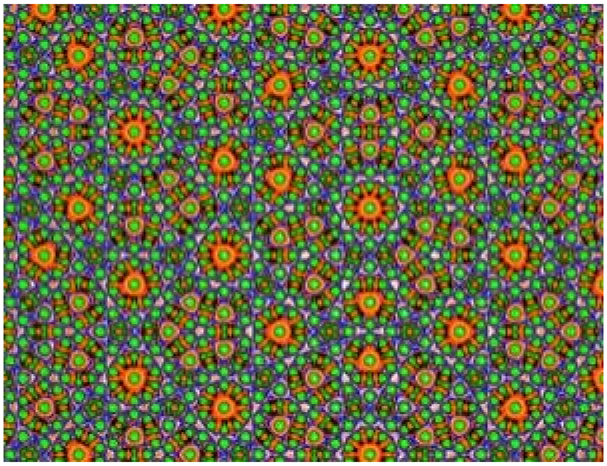


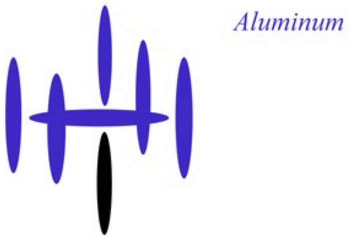
image: Eric Heller/Science Photo Library

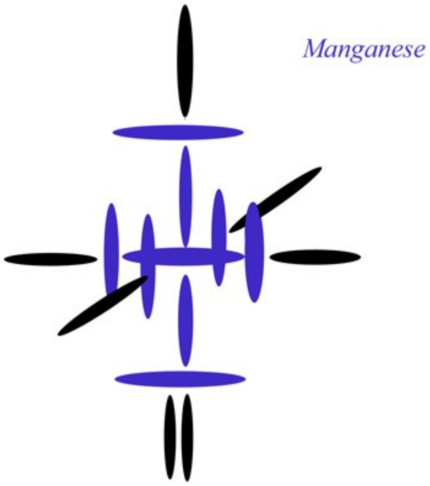
by Miles Mathis

On January 23, 2012, *New Scientist* published a series called "Impossible reactions: Five Chemistry Rules Broken." The first of these is Dany Shechtman's quasi-crystal, for which he won the 2011 Nobel Prize in Chemistry. This after being ridiculed by Linus Pauling in 1984 for suggesting that crystals could take a pentagonal structure (as diagrammed above by Eric Heller).

Although Shechtman was proved right, we still have no mechanical explanation of the cause of the pentagon. How exactly can Manganese and Aluminum create an alloy of this shape? Until now, no one knew, not even Shechtman. But my nuclear diagrams allow me to suggest an answer, and to make a prediction.

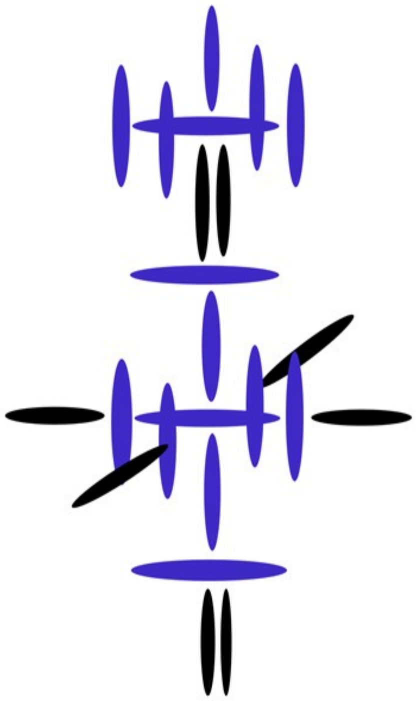
Here are Aluminum and Manganese:





The blue disks are alphas and the black disks are protons. See my paper on nuclear diagramming for more on this. In short, the protons and alphas channel charge through the nucleus by spinning. This rids us of the need for the strong force, since the charge is no longer a force between protons. It also gives the charge field a shape and direction at all points, internally and externally. This provides the method for atomic bonding, and rids us of the need for electron bonding. The electrons are still present, but they are not orbiting the nucleus. Some are contained in the alphas and some are circling the holes in the outer protons. But they have a reduced role in my mechanics: so reduced that I don't even bother to diagram them in most cases. They are there during bonding, but they don't *cause* bonding.

In looking at molecular shapes and bonds, we follow the charge field as it exits the nucleus, not the electrons. Here is how Manganese and Aluminum create an alloy:

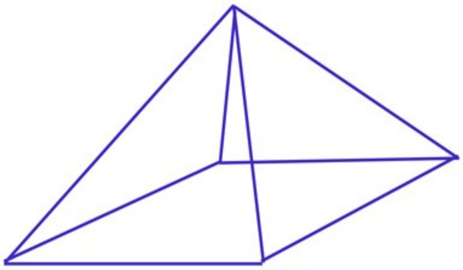


Manganese-Aluminum

Each disk is like a compact disk, with a hole in the middle. Since the disks are blue here, they are composed of two protons. That means they can also take two protons in each hole. You can see that we have the perfect plug between Manganese and Aluminum, creating a very well-balanced molecule or alloy. But why do we have a five-pointed charge field here, instead of six? At first glance, it appears that the Aluminum simply extends the top side of Manganese, which should keep the crystal hexagonal. But no, the axial (north-south here) charge channel has been short-circuited, due to at least two things. The first thing to notice is that we have two carousel levels in this molecule, and that they are in a line. By carousel level, I just mean the four blue disks around the central one. Both Manganese and Aluminum have one. The carousel level acts to channel charge out to the side. In other words, if the axial level is the z axis, then the carousel level exhausts charge in the x,y plane. Since we have double carousels, we have double x,y exhaust of charge, short-circuiting the z exhaust. We also have the same number of protons north and south. The blue disk up top stands for two, and then we have the two I have drawn separately at the bottom. So there is no differential from top to bottom, and a weak pull of charge through the axial level. The axial level is stronger in atoms like Fluorine, where we have two protons top and only one bottom, creating a differential.

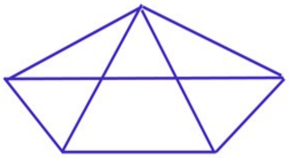
Since charge is partially or mostly nullified top to bottom here, we have a charge field that is mostly square, and strong in the x,y plane. But the z axis cannot be skipped completely, since we have the entire Aluminum nucleus on top. And we have two separate x,y planes, since each carousel level will create its own. There isn't much separation between the two, but the separation is enough to force us to diagram the z axis.

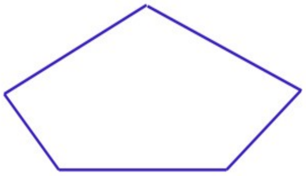
What this means is that we basically ignore the lower z axis. We ignore the bottom two protons, since they aren't exhausting much charge. This gives our structure the form of a pyramid, like this:



Already you can see the five-*point* structure. But we need a pentagon, not a pyramid, we are told. A pyramid has five points and five faces, but not five sides in any one plane. So the question becomes, "Are we sure Shechtman found five sides in *one* plane?" No, because we are told he discovered the structure by firing beam of electrons that reflected off layers of the material. Notice that is *layers*, plural. Beams in real experiments don't bounce off just one plane of material. Everything that happens is 3D.

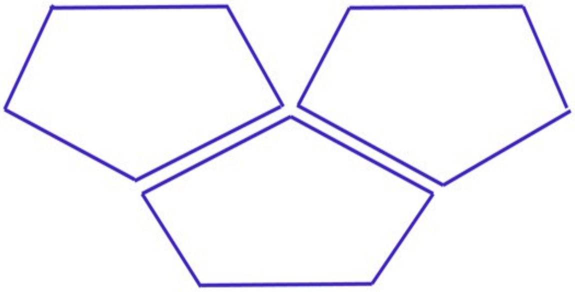
So instead of drawing our pyramid to make it look like it is in 3D, let us draw it so that it looks like it is in 2D:





First I drew a pyramid 3D, then removed the third dimension. That is what 3D looks like in 2D. The pyramid becomes a pentagon. But it isn't an equilateral pentagon, which is why Shechtman's quasi-crystal "never repeated exactly."

We can see this when we start stacking our pyramids to create the alloy. We have to ask how these Manganese-Aluminum molecules will combine with themselves. Well, you have to take four of these diagrams I have just drawn, turn them upside down, and plug them into a central molecule. The carousel prongs of Manganese fit right into the carousel holes of Aluminum, you see. So we get a lovely double bond between each molecule. But this means that those four pyramids are inverted. In 2D, the pentagons would be inverted. So we get a building block that looks like this in 2D:



There will be two more pentagons forward and back, but if I diagram those it will just confuse things.

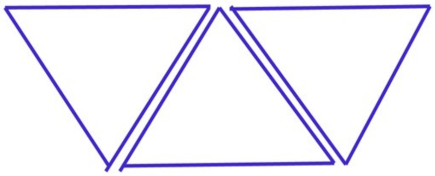
Notice that gives us a five-fold structure at not just the first level, but also the second. The first level is the pentagon. The second level is the five pentagons fitting together to create the basic building block. Again, that last diagram above is understood to have two more upside-down pentagons plugged in forward and back. **That is the building block of the alloy.**

Of course this means that the angle of diagramming makes a great difference. The angle of diffraction should make a difference as well, for the same reason. In other words, according to my analysis, there should be two separate angles of firing electrons at Manganese-Aluminum that *won't* show this pentagonal structure. But since those are two angles out of an infinite number of possible angles, they haven't yet been stumbled upon in the lab. You would have to be looking for them to find them.

What are they? Well, we just have to study the pyramid. If you look at the pyramid from most directions, it will have five points. But if you look from directly above, it will have four, and if you look directly from a side, it will have three. So the electrons would have to be fired straight down on the structure, or straight from a side. *Any* deviation from those two angles will show the pentagonal structure.

The structure from the side may also be four instead of three, if the electron beam hits across several molecules instead of just one. In that case, the beam would "see" this:

That would read as a trapezoid, not as a triangle.



I don't know how the experimenters will calculate those positions. If they find one, the other will be 90 degrees from it, obviously; so if they stumble upon the three point structure they can easily find the 4 point structure, or the reverse. But how can we calculate the first one?

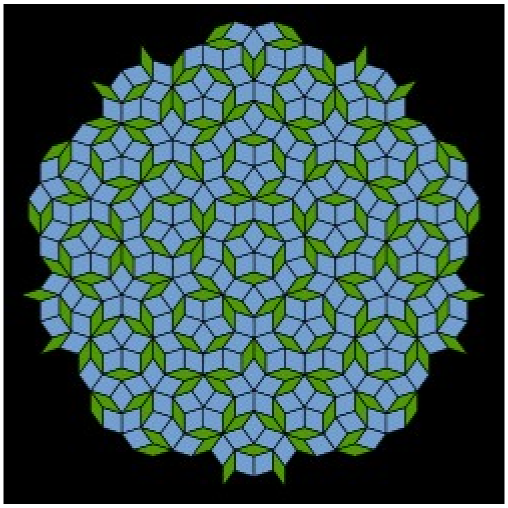
One way might be to diagram straight from the data (if they can do that). This will give them a pentagon with different length sides. They can then use photoshop to read the pentagon as a pyramid (there are programs which automatically read the third dimension now). The program will then turn the image until it becomes a triangle or square. The program will tell them how many degrees the image was turned to go from the pentagon to the triangle. They can then turn their apparatus that many degrees and fire again.

The only problem with that is they won't know which point of the pentagon is the top. They must tell the computer that, since the computer won't know. They may have to try five times to find the right solution.

There is also the possibility that the structure is so “quasi” that the z axis isn't kept stable throughout the alloy. This would prevent *any* angle of firing from being pure, and would destroy my prediction. However, I feel pretty confident that the molecules will keep their pure planar structure even in this quasi-state or five-fold state. Since the atoms maintain a 90 degree angle between the axial level and the carousel level, any charge structure, no matter how complex, should retain that orthogonal lock, insuring that my analysis holds.

The electron beam should also be kept as narrow as possible. Any width to it will fuzz out the angle. If the electrons spread out at all from the source, they will cause their own angles in the data, ruining the angle we are hoping to find. To make any more recommendations I would have to study the actual apparatus.

Now let us look at how this crystal structure has been mis-assigned to the Penrose tiling.



Wikipedia tells us:

It is a quasicrystal: implemented as a physical structure a Penrose tiling will produce Bragg diffraction and its diffractogram reveals both the fivefold symmetry and the underlying long range order.

But the Penrose tiling cannot be implemented as a physical structure, because the tiling is 2D and a physical structure is 3D. Also, the word “implemented” is imprecise. Implemented how? How does this 2D tiling implement a Bragg diffraction and and five-fold symmetry? The Penrose tiling has never been implemented as a physical structure, you know. It *can't* be, because it is 2D. What they mean is that the Penrose tiling has been *assigned* to the quasi-crystal structure of the Manganese-Aluminum alloy, and that the M-A structure produces the Bragg diffraction. The tiling itself doesn't produce a Bragg diffraction with five-fold symmetry, because there aren't any pentagons there. At the lowest scale, we have rhombi, as you see. At the next scale we have either star decagons or circle decagons. Decagons are not pentagons, no matter what anyone says. We also have some hexagons and octogons in there, but no pentagons.

The article at *New Scientist* tells us,

> In 1981, crystallographer Alan Mackay at Birkbeck College in London found that atoms sitting at every corner of such a Penrose tiling would produce a diffraction pattern with fivefold symmetry.

That's a fudge if there ever was one. The very sentence is so squishy most people won't even bother to try to make sense of it. What it means is that instead of letting the atoms have the structure, we let the structure apply to the space between the atoms, and treat the atoms as points in the tiling. The problem there is that it dodges the question of how the atoms create the structure, which is the fundamental question. In other words, it begs the question. It just takes the Penrose tiling as given. Mackay should be expected to prove that the M-A alloy is a Penrose tiling, since that is what we have been sold. Instead, he just assumes it. He pushes the math to try to show some five-fold structure to the Penrose tiling (and doesn't even succeed at that). But *even if* he had shown some five-fold structure to the Penrose tiling, that wouldn't have proved or even indicated that the M-A alloy was a Penrose structure. Lots of things have five-fold structure, and the Penrose tiling is just one of those things.

Another problem is that Mackay claims to be able to make the Penrose tiling into rhombohedra in 3D. But rhombohedra aren't five-fold in any way. Using rhombohedra instead of rhombi doesn't solve anything. It just creates a more complex Penrose tiling, but does not answer any of the mysteries I have just answered. Wiki says,

> Alan L. Mackay showed experimentally that the diffraction pattern from the Penrose tiling had a two-dimensional Fourier transform consisting of sharp 'delta' peaks arranged in a fivefold symmetric pattern.

That is an outright lie, because you *can't have* a diffraction pattern from a 2D Penrose tiling. It is impossible to create an experiment where you fire anything through a 2D object. There is no such thing as a 2D object! And if you fire anything through a 3D rhombohedral Penrose tiling, you have to specify a direction. Your pattern must depend on your direction of firing. But from his abstract, I find no indication that Mackay actually built a 3D Penrose tiling that could create his diffraction pattern. It appears he only did math, which is not "experimentally."

To back up Mackay, others such as Caspar and Fontano have misdirected into Fibonacci pentilings, which really do have pentagons in them to start with. They then elide from pentilings to decagons, trying to make you think that their work on pentilings confirms the five-fold symmetry in quasi-crystals. These are the first two sentences of their 1996 abstract:

> To demonstrate that crystallographic methods can be applied to index and interpret diffraction patterns from well-ordered quasicrystals that display non-crystallographic 5-fold symmetry, we have characterized the properties of a series of periodic two-dimensional lattices built from pentagons, called Fibonacci pentilings, which resemble aperiodic Penrose tilings. The computed diffraction patterns from periodic pentilings with moderate size unit cells show decagonal symmetry and are virtually indistinguishable from that of the infinite aperiodic pentiling.

But clearly pentilings prove nothing about rhombi. We can see the Penrose tiling above with our own eyes. It has no five-fold structure at the necessary levels. Period. Its structures are 4, 6, 8 and 10. The only five-fold structure it has is the five flowers around the central flower. But even that is a six-fold structure, since you have to include the central flower. And that structure is at too high a level to explain as atomic or molecular structure. We need pentagons at the first or second level, and they just aren't there. If you have to create five-fold structure by some mathematical trick, it doesn't count. The structure is required to be there, in the first glance, as it were. With mathematical tricks, you can prove anything. Also notice that Caspar and Fontano admit that they are "computing" the diffraction patterns. As with Mackay, that is not an experiment. They are not building 3D Penrose tilings or Fibonacci pentilings, and then firing real objects at them to create real diffraction patterns.

Of course, I am not either. I have built nothing and run no experiments. However, my models are much more mechanical than theirs, because I am at least trying to explain the patterns from the atoms and molecules themselves, rather than from other patterns. Their structure is pinned only to quilt patterns and pushed math. My structures are pinned straight to the molecules, and the molecules are built with simple mechanical rules. It is the shape of the molecules, and the shape of the emitted charge field, that determine the both the structure and the larger pattern. Yes, my structure has some similarity to theirs, but

1) It is NOT based on either the Penrose tiling or the Fibonacci pentiling. It is based on the pyramid.
2) It did not evolve out of anything others have done. It evolved out of my nuclear diagrams and my definition of charge.
3) It is completely mechanical at all points. I have not done anything to match other models or math. I have matched only the requirements of the the charge field. Since the charge field determines all the motions, it must determine the structure at all scales.
4) I have made a prediction with my new structure, something they have not done. A lot of people have tried to ride Shechtman's coattails by fiddling with math, but I am immediately going beyond him. I am not questioning his basic findings, but I *am* questioning all the interpretions that have been piled on it from the beginning. Others have seen the quasi-crystal as an open door for all their mathematical games. I see the quasi-crystal as another test of my nuclear diagrams.

The reason that the Penrose tiling has some mathematical and structural similarities to the M-A quasi-crystal is that—as my first nuclear diagrams show—the 2D structure of the molecule is in fact rhomboid. If we suppress the z axis, we are down to the carousel level of the molecule. The carousel level is four-sided, and will look that way to any measuring device that is not directly to the side. In other words, any electrons fired from any direction except the x,y plane will "see" the four-sided structure of the carousel level protons. Unless we put our machine right on the equator of the atom, we will get a reflection of a tilted carousel level. And, although the carousel level is actually square locally, it will be seen as rhomboid from any angle except directly above. The only way to see the carousel level as square with our machine is to be firing electrons directly down on the atom from above (z axis). But since our machine is localized as well, we could do that only with one line of atoms. The electrons would have to spread out to hit atoms not directly below, and when they do that, they will see rhomboids agains.

So you see that a large part of the answer is determined by perspective. Many people haven't understood what good it does to have a physicist who is also an artist look at all these things, but this is the good it does. I see things others haven't seen because I know combinations of things most other physicists don't know. This is why we should welcome generalists in all fields. Generalists can synthesize answers that specialists cannot.

As a sum-up, it is also probably worth quoting the first sentence of the *New Scientist* article, written by Philip Ball:

Of all people, chemist Linus Pauling should have appreciated boldness in a scientist, even if they turn out to be wrong.

So far, my boldness hasn't been much appreciated. It is easy to say something like this after a fellow has won the Nobel Prize. It isn't so easy to say it or think it when that fellow is shooting holes in your pet theories. Current physicists aren't very interested in boldness, it would seem, except thirty years later when everyone involved is long retired or dead.