Stellar Metamorphosis: Gas Giants evolve into Gas Dwarfs

Daniel Archer I
D_Archer@live.nl
danielarcher369.wordpress.com
08 December, 2021
Amersfoort, NL

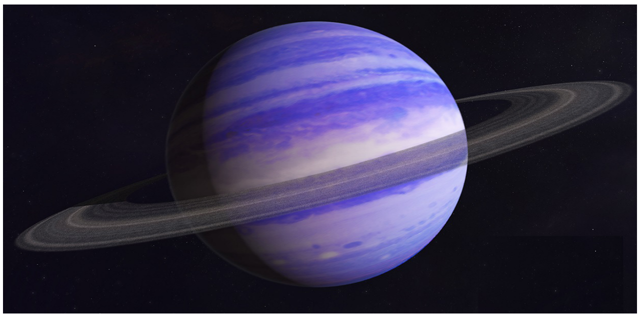
Abstract: In Stellar Metamorphosis[1] gas giants evolve into gas dwarfs. In this paper it is shown why and how this happens, supporting evidence is provided and some predictions. I also provide more detail on the intermediate stage of grey dwarfs.

In our solar neighbourhood we are very familiar with Jupiter and Saturn; the so called 'gas giants'. We also have 'gas dwarfs' in our system like Uranus and Neptune. Between these 2 types there is a lot of size difference, the intermediate size between these 2 types is occupied by 'Grey Dwarfs'[2] in Stellar Metamorphosis. You can see the evolution of the astron[3] types we are looking at in this paper in the table below; a part of the Astron Classification table[4]:

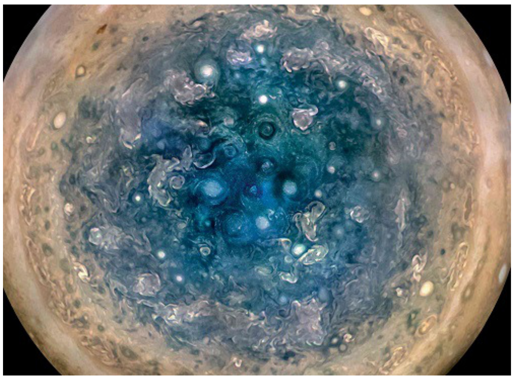
Time	Population	Type	Temperature (K)	Size (R☉)	Examples
↓	II Gas	Gas Giant	125-500	0.08 -0.12	Jupiter / Saturn / WISE 0855−0714
		Grey Dwarf	125>	0.04 - 0.08	Gliese 15 Ac
		Gas Dwarf	N/A	0.03 - 0.04	Neptune / Uranus / Keppler-11e

Temperature in Kelvin, Size is in Solar Radius

An example of a Grey Dwarf is Gliese 15 Ac (also know as Groombridge 34 Ac), below an artist concept:

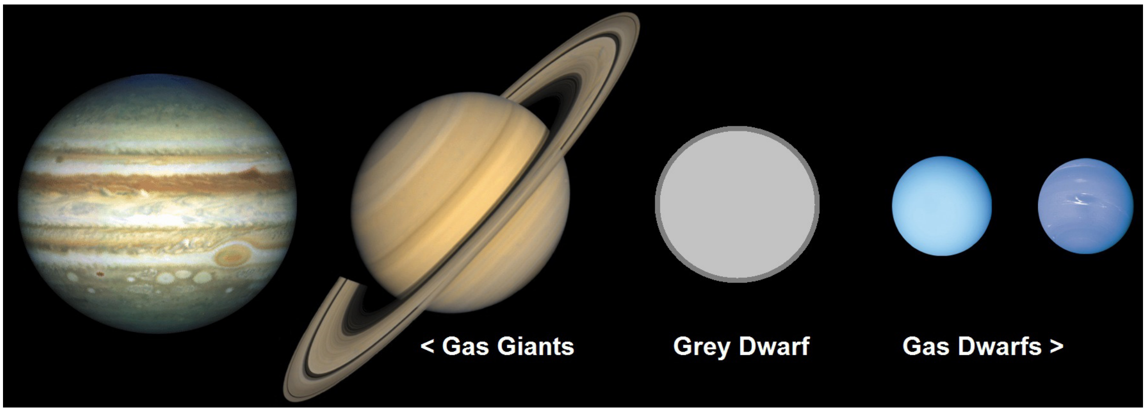


The artist concept could be close to how a grey dwarf would really look, there would be more white clouds than Uranus/Neptune, there could also still be some brown clouds. Below you can see the south pole of Jupiter:



At the south pole of Jupiter you can already see blue color (this is methane); over time more parts of Jupiter will become blue as more atmosphere is lost and more gas turns to liquids/solids. This will make Jupiter shrink over time. The same goes for Saturn and of course any other gas giant.

This picture helps to visualize the size loss in time and the relative sizes between the different types:



So far it is established that 'Grey Dwarfs' are part of the evolution of astrons (stars/planets) and thus part of Stellar Metamorphosis. To go from a gas giant like Jupiter to a Grey Dwarf and then to a gas dwarf like Neptune; a lot of gas has to be lost, explained in section **A** (atmospheric loss). The astron will also shrink due to this atmospheric loss but also due to phase changes, later explained in section **B** (phase changes).

A) Atmospheric loss

Planetary atmospheres are lost over time as this is observed to happen, generally mainstream astronomy has agreed this happens; an overview can be found in this article published in Scientific American: The Planetary Air Leak[5]. I quote:

"Many of the gases that make up Earth's atmosphere ***and those of the other planets*** *are slowly leaking into space. Hot gases, especially light ones, evaporate away; chemical reactions and particle collisions eject atoms and molecules; and asteroids and comets occasionally blast out chunks of atmosphere."*

Atmosphere (gas) escapes because the astron can not maintain it, no astron is a closed container; gas can only be conserved in a closed system. Astrons are established to be open systems[6] and thus they must lose gas (mass) in time and thus evolve.

How?

There are a few mechanisms for gas to escape into space and some or all of them apply at different stages of astron evolution to varying degrees. I will list all mechanims that are currently known and nominate the last one (charge exchange) to be the mechanism responsible mostly for atmospheric loss in the gas phase of stellar evolution.

- Jeans escape
- Hydrodynamic escape
- Photochemical escape
- Sputtering escape
- Polar wind escape
- **Charge Exchange escape**

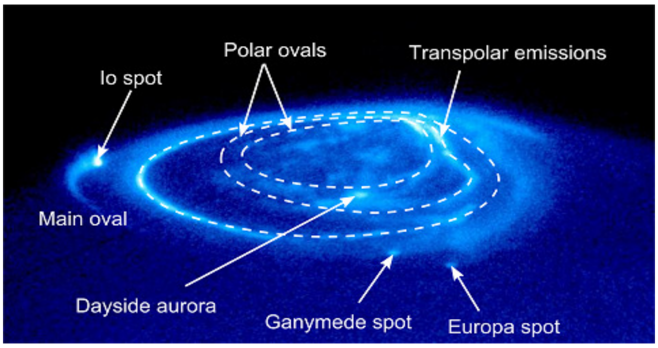
Jeans escape is simply said; a kinetic way for gas to escape, gas is never still it always moves and gas molecules can bump into each other. With enough kinetic energy (temperature, bumping speed) a gas molecule can reach the escape velocity, this is possible on gas giants, grey dwarfs and gas dwarfs but only minimally, gravity is high and thus the escape velocity too, but it does happen. It happens more for so called hot jupiters, if a gas giant is closer to their parent star there is more thermal energy and jeans escape happens more readily.

This higher temperature can cause **Hydrodynamic escape** and happens more again on hot jupiters (as that is observed). The mechanism is through extreme UV (ultra violet) light, atmospheres absorb the light, molecules are heated up and lighter ones escape, hydrodynamic escape happens when lighter molecules drag (or bump) heavier molecules with them and make them escape too.

Photochemical escape happens when UV light breaks down a molecule, this is called photodissociation, the resulting atoms can then achieve enough speed to escape the atmosphere. This can happen on gas giants but it would be a very small amount if at all. This happens with 'hot jupiters' moreso.

Sputtering escape happens more (is more pronounced) on astrons without atmosphere, it is an interaction with the solar wind. The faint atmosphere that astrons with very small atmospheres (like Mercury) have can be more readily impacted by solar wind atoms and erode the atmosphere (and also erode the surface). Astrons with a magnetic field deflect most of the solar wind, but some sputtering (interaction with the solar wind) still happens and an insignificant but not zero amount does escape this way from gas astron atmospheres.

Polar wind escape is possible on all astrons that have a magnetosphere, the poles are open (magnetically), ions/electrons freely move in and out, the outgoing ions can drag atmosphere (gas) out into space. The driving force of magnetospheres is the charge field, a field of real photons that are recycled by all astrons; i explain this in my paper about the charge field[7], see reference 7. Polar wind escape happens on all gas type astrons, the degree of which still needs to be examined more, but it is not an insignificat amount. We do have data about interaction of Jupiter and its moons and the imprint they have on the poles, see picture:



I would say that polar wind escape is a form of charge exchange, leading to:

Charge Exchange escape

The main driver of atmospheric loss for gas type astrons is charge exchange escape. I quote wiki:

"Ions in the solar wind ***or magnetosphere*** *can charge exchange with molecules in the upper atmosphere. A fast-moving ion can capture the electron from a slow atmospheric neutral, creating a fast neutral and a slow ion. The slow ion is trapped on the magnetic field lines, but the fast neutral can escape"*

Gas giants have strong magnetospheres so the solar wind is not the main driver it is the interactions of the atmosphere with the magnetosphere. At any moment in time there are fast moving ions (in/from the magnetosphere) that readily interact with the atmosphere, the interaction as described in the wiki quote has gas escaping. This is a process that happens likely in bursts, there is a loading phase and then a sudden burst where (large) quantities of gas (atmosphere) are lost into space (or into the magnetosphere). Evidence for such bursts were found at Jupiter[8], see reference 8. A few choice quotes from reference 8:

"we found evidence that the Jovian magnetosphere supports a process, in which the system releases excess mass, angular momentum, and pressure permanently fed into the system by the efficient internal plasma sources."

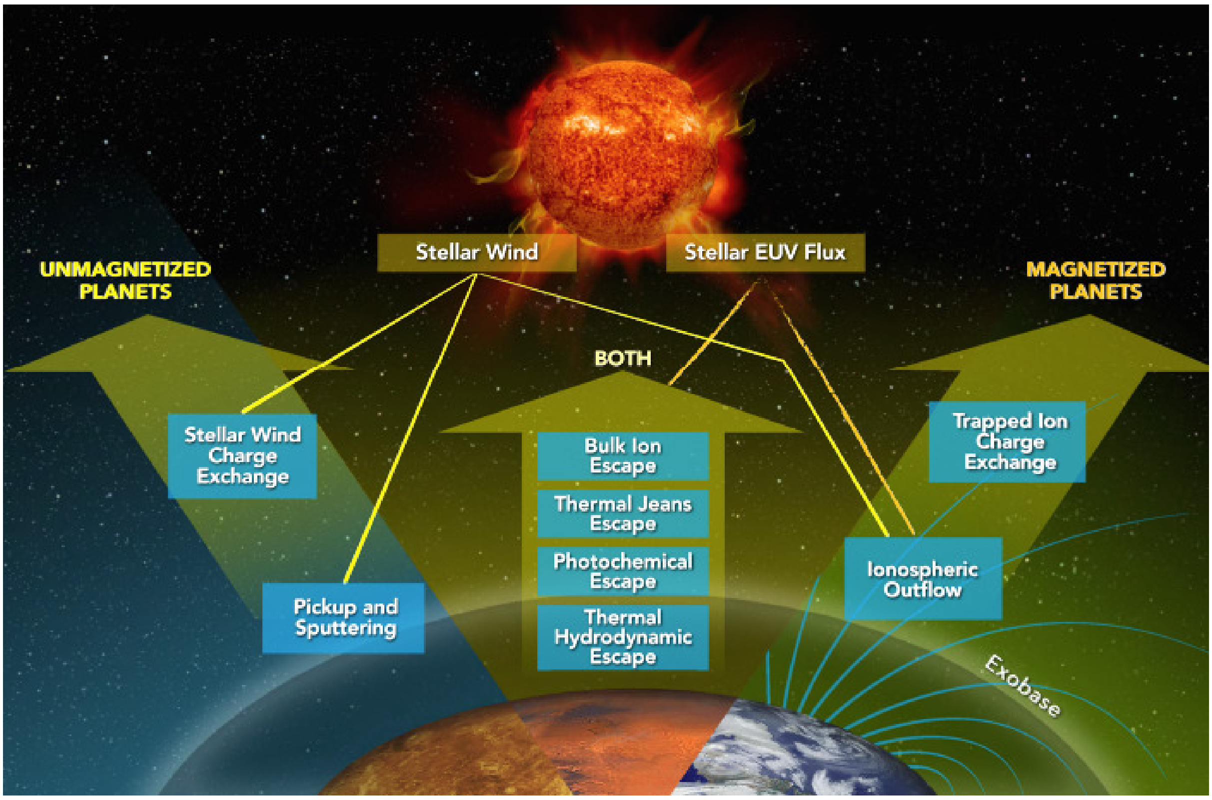
"the process appears to be of transient, impulsive nature rather than being a continuous, steady state process"

"We tentatively suggest that the particle flow burst events are part of the source process of the auroral dawn storms and auroral flares observed with the Hubble Space Telescope"

“In addition to fundamental importance for the dynamics of the Jovian magnetosphere the process is also a straightforward mechanism to accelerate particles and release them into interplanetary space. It constitutes a very efficient source of impulsive nature for interplanetary Jovian particles.”

A link is made between charge exchange escape and also polar exchange escape (ie auroral flares etc), indicating as i suggested that polar exchange escape and charge exchange escape have similar mechanisms.

Generally this is a new field and there is not enough evidence to say something conclusive about loss rates, we just know that astrons lose atmosphere (and thus mass) over time and there are many mechanisms for this to occur; this paper[9] from 2020 gives an overview, see reference 9. The following picture from that paper sums it up:



From the image: Ionospheric outflow is a form of charge exchange, or as now understood an interaction between an atmosphere and the magnetosphere of an astron.

So loss rates are not yet known, but we can say that it takes hundreds of millions to billions of years, so the losses do not have to be that great to make an impact, there is enough time for any astron to lose atmosphere and there are enough mechanisms and one likely main mechanism of charge exchange escape.

B) Phase changes

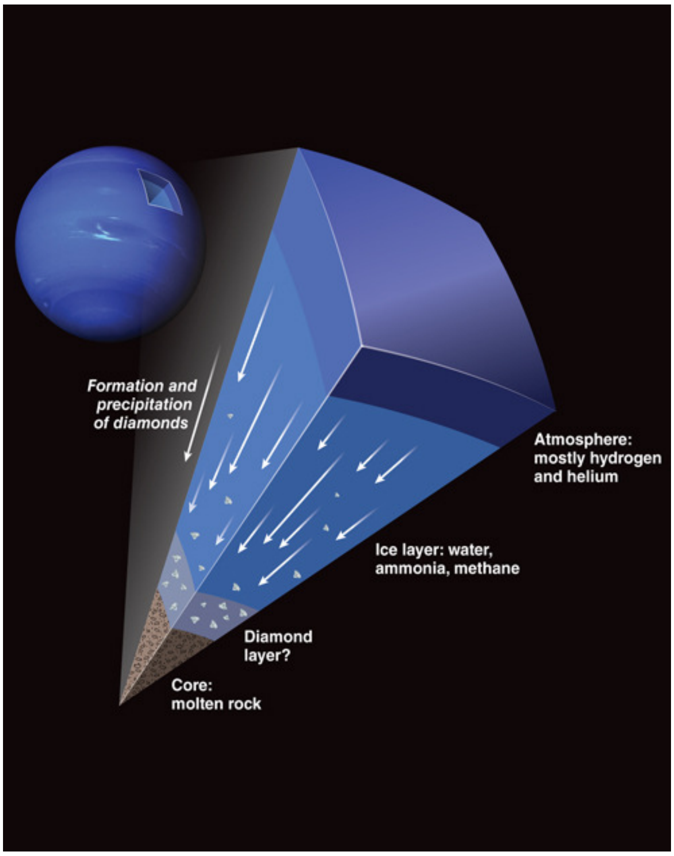
Beside the mass loss causing astrons to shrink; a large part of any shrinkage is due to phase changes. Gas occupies a lot of space, further towards the core, gas astrons are more condensed and as a gas giant evolves it gets more and more condensed, gas turns to liquid and solids, causing an overall shrinkage.

There are astronomers that say it could rain diamonds on gas dwarfs, this American Scientist article[10] talks about raining diamonds on Neptune and Uranus, quotes:

“pressures more than one million times greater than the atmospheric pressure on Earth compress the so-called ices into a hot, dense fluid”

“Under such heat and pressures, ammonia and methane are chemically reactive. Scientists have modeled exotic processes—including diamond formation—taking place between the compounds deep within the ice layers.”

Picture from the article:



Diamond formation is possible under these conditions, so it could happen. On Earth we find diamonds in the crust, so if diamonds are formed on Neptune and Uranus they sink to a layer above the core, this is also visualized in the picture above. Later in the Ocean world stages where the crust forms these diamonds become part of the crust. I was always taught diamonds formed in the crust, which is also possible as there is enough pressure and heat in that region too.

Other solids could be formed too under high pressure, either in the dense pressure atmosphere and/or closer to the core. And this can happen in all gas type astrons. This happens beside/alongside the gas deposition formation of the iron/nickel core.

Gases also turn liquid at lower regions thus also compressing and making the gas astron shrink.

Further; the gas giants are chemical factories, so they also make all kinds of molecules, molecules generally occupy less space then loose atoms and this makes them shrink as well.

This concludes section B, i found a quote in the diamond article that i would like to share and comment on:

"Determining the properties of the carbon layer could reveal whether or not Neptune and Uranus formed from a rocky protoplanet core billions of years ago"

Comment: No, Neptune and Uranus did not form from a rocky protoplanet core billions of years ago. Billions of years ago they were shining stars and currently they are making their own rocky protoplanet core as we speak, they are continuing evolving structures.

In the abstract i said i would also make some predictions, so here goes:

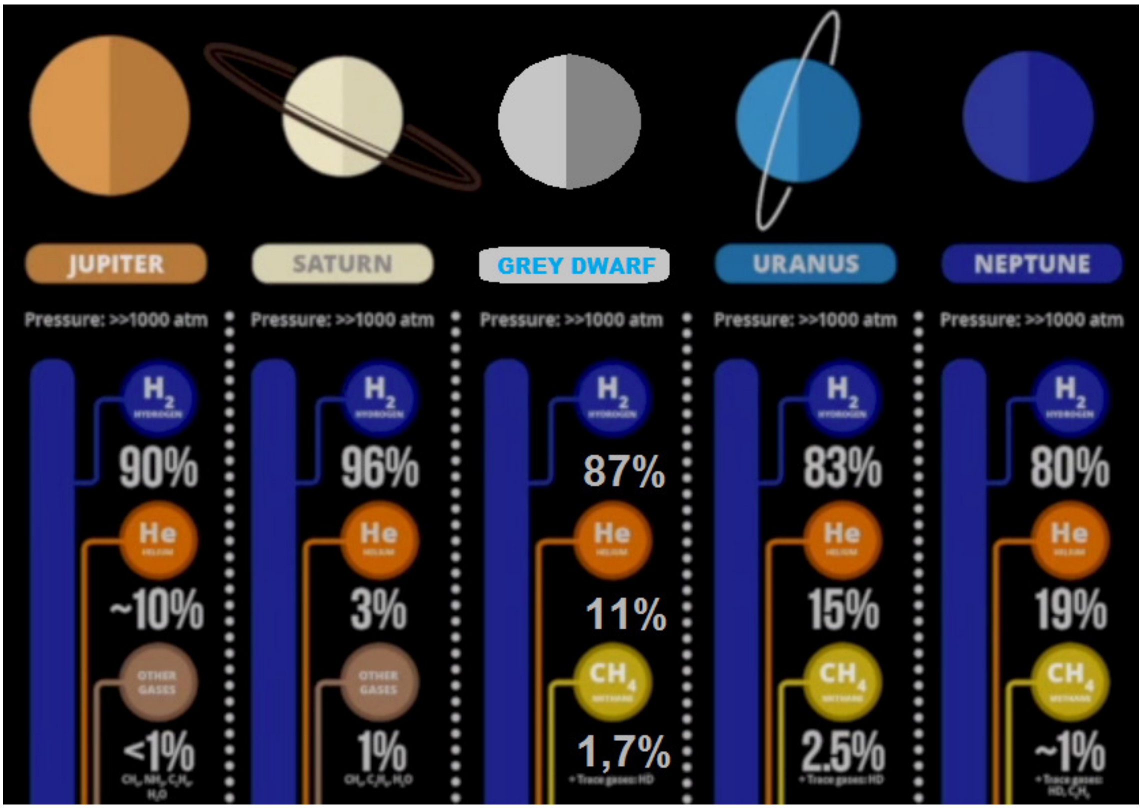
1) with the upcoming TESS and other telescopes that can observe more planets than ever, astronomers will find increasing evidence of a variety of gas astrons that all lose atmosphere, not just 'hot jupiters'.
2) They will find more grey dwarfs and will be forced to classify them as their own separate type, not

comprehending that grey dwarfs are part of a continuum.

Grey Dwarfs

As grey dwarfs are the intermediate stage between gas giants and gas dwarfs it is needed to give them some characteristics of their own. As said in the beginning of the paper they look different from gas giants in that their bands are 2 to 3 colers of white, brown and blue, compared to gas giants, mostly brown or brown and white. With gas dwarfs being mostly blue/green.

I made a picture showing how their top atmospheres are composed differently; future observations of grey dwarfs should (prediction 3) generally conform to these ratios:



Their size is in between gas giants and gas dwarfs as already said, the same goes for their masses. There could also be unique chemcial processes that only occur on grey dwarfs and they can have storms that dwarf storms on gas giants and gas dwarfs, this because the atmospheric changes are generally greater, going from very light gasses to heavier gasses, the changes in appearance are much more dramatic. They could have multiple spots like the great red spot on Jupiter, but it would be great blue spots at sub-polar and/or above and below equatorial regions or possible asymmetric circulation (prediction 4), ie more chaotic.

A picture of the atmosphere of Jupiter; a grey dwarf would have less brown, more blue and possibly more chaotic storms.

“tempus narrabo”

Reference on the last page

References:

1) J. Wolynski, 2012, An Alternative for the Star Sciences: http://vixra.org/pdf/1205.0107v9.pdf

2) J. Wolynski, 2013, Stellar Metamorphosis: Grey Dwarf Stars: https://vixra.org/pdf/1308.0008v1.pdf

3) M. Zajaczkowski, 2015, Star and Planet: Stages of Astron Evolution: http://vixra.org/pdf/1510.0381v1.pdf

4) D. Archer, 2017, Astron Classification Table: http://vixra.org/pdf/1712.0460v1.pdf

5) David C. Catling and Kevin J. Zahnle, The Planetary Air Leak, Scientific American, May 2009, p. 26 (accessed 25 July 2012): http://faculty.washington.edu/dcatling/Catling2009_SciAm.pdf

6) J. Wolynski (2017), Stars are Dissipative Systems in the General Theory: http://vixra.org/pdf/1710.0305v1.pdf

7) D. Archer (2018), The Charge Engine of Stellar Evolution: https://vixra.org/pdf/1811.0168v2.pdf

8) J. Woch, N. Krupp and A. Lagg, 2002, Particle bursts in the Jovian magnetosphere: Evidence for a near-Jupiter neutral line: https://agupubs.onlinelibrary.wiley.com/doi/pdfdirect/10.1029/2001GL014080

9) Many authors (2020), Atmospheric Escape Processes and Planetary Atmospheric Evolution: https://authors.library.caltech.edu/106343/1/2019JA027639.pdf

10) American Scientist, On Neptune, It's Raining Diamonds: https://www.americanscientist.org/article/on-neptune-its-raining-diamonds (multiple references at the end of this article)