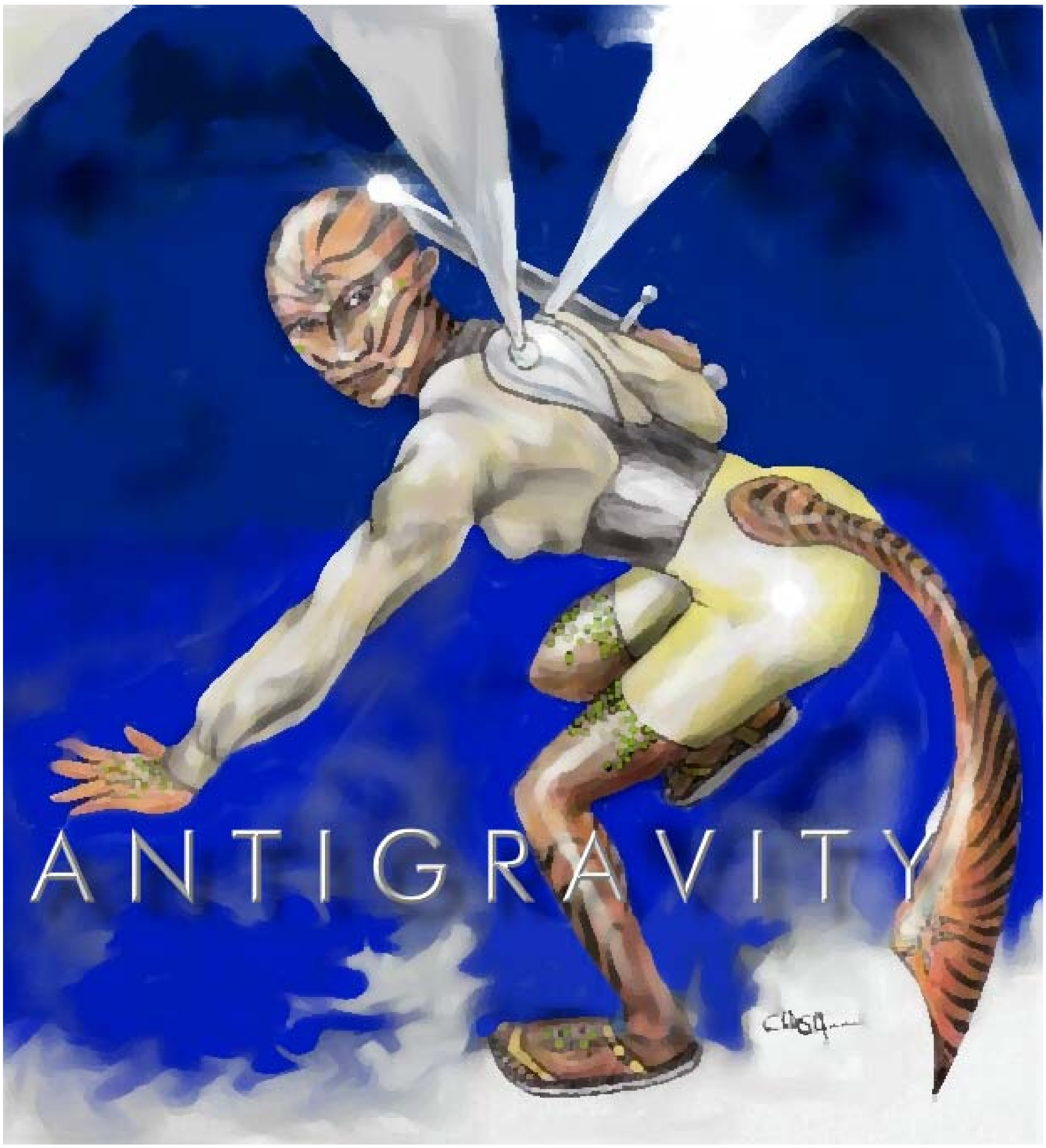
STARCLUSTER



STARCLUSTER
Anti-Gravity

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StarCluster Anti-Gravity

The great technological breakthrough of Tech Level 9 is gravitonics, the artificial creation of gravitational field forces. From this science stems many of the other TL9 innovations, such as G-drive.

Starcluster antigravity utilizes A-grav plates. A standard antigravity plate produces a uniform field of up to 1 gravity for a distance of 1 meter from the active side of the plate, dropping to zero beyond that point. The distance of the effect can be increased, but with a proportional decrease in the strength of the effect. For example, a standard plate could produce a 0.1 gravity field for a distance of 10 meters. The strength of the effect can be regionally diminished below the maximum as desired, but this does not increase the strength in other regions. That is, at a 10 meter distance, the maximum gravitational field that can be produced is 0.1 gravities, even if it is zero up to 9 meters from the plate. Where stronger fields are desired, this is accomplished by stacking plates. The effect is linear: ten stacked plates can produce a field ten times as strong as a single plate. To produce one gravity in a region 3 meters high (typical room height), one would use three stacked gravity plates, each producing 1/3 g over a 3 meter high region. In habitable area of ships, plates may be stacked on one deck with the induced A-grav field spanning a number of floors. Tractor beams are also typically constructed by this means, stacking large numbers of gravity plates.

Standard plates are 2.5 mm in thickness, and mass 5 kg per square meter. Plates typically are produced in square or hexagonal shapes, but can be produced in any planer shape. They must, however, be flat to project fields at significant distances. At TL9, the minimum size A-grav plate that can be produced is 1 square meter in area. At TL10, plates with areas as small as 10 square centimeters can be produced.

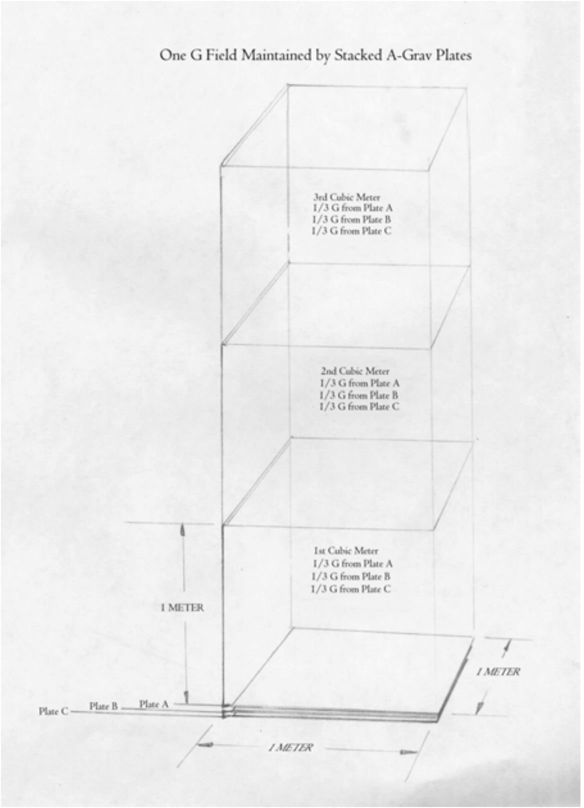
Within the region of effect, artificial gravity can be produced in any desired direction. At TL9, only simple gravitational gradients and block area effects can be produced, but at TL10 quite subtle gravitational variations are possible.

A-grav fields are normally emitted normal to the plate surface, however, the fields can also be emitted at an angle, the effective plate area being equal to the projected surface area; that is, the plates effectiveness falls off as the cosine of the angle from the normal.

Gravity plates are used for several purposes. One is to provide artificial gravity within a spacecraft. For a spacecraft with an average density of 0.25 tons per cubic meter, a 1-g A-grav field can be produced over the habitable half of the ship's volume by dedicating 1% of the ships mass to A-grav plates.

The other use of A-grav is to propel a craft by the reaction produced from inducing an artificial gravity field in another body (a planet or a spacecraft) For example, if a gravity plate is used to produce a 1-g downward force over a volume of earth, it will produce a reaction force sufficient to levitate a mass equal to the mass contained in that volume of earth. Using this effect, A-grav can be used to levitate planetary flying vehicles and propel spacecraft from ground to orbit.

A-grav fields do have a limit to the amount of matter they can affect. The matter affected cannot exceed 100,000 tons per square meter. While this seems like a lot, if effectively implies that a A-grav field cannot penetrate more than 100 kilometers through water, or 20 kilometers through a typical planetary crust. Thus an aircar flying at a 20 kilometer altitude, projecting its A-grav field a deep as possible, would only be able to have half the field within the surface of the planet, and so its lift would be only half that which could be induced close to the surface. A spacecraft lifting to 180 kilometers (low orbit) could only lift 10% of the mass it could lift near the planet's surface. For a craft to reach this height on A-grav drive, it would need A-grav plates massing 1% the total mass of the craft. (The tenfold dropoff due to height is partially counterbalanced by the fivefold increase in effect for a planetary crust with a specific gravity of 5.)



Height above surface (km)	Lifting weight (kg, 1 standard plate)
0	5000
5	4000
10	3333
15	2857
20	2500
40	1666
60	1250
80	1000
100	833
140	625
180	500

A-grav fields are also used for grappling with other spacecraft. This is most effective at distances comparable to the size of spacecraft to be gravitationally affected. For example, if one grapples a spacecraft 10 meters across from a distance of 30 meters, only 1/3 of the gravity field is used effectively. The rest of the field volume is in empty space. Thus close in repair and weapons pods are easily and strongly coupled to the ship they accompany. With 10 square meter plates, a 4 ton pod could couple to a 20 meter diameter spacecraft (average density 0.25 tons per cubic meter) at a distance of 5 meters with a strength sufficient to accept 1 g accelerations. Even at much larger distances, A-grav could be useful for drawing close to cooperative or derelict spacecraft: the ships could be accelerated together at 1/100 g even if separated by a kilometer, sufficient force to draw the ships together within a matter of a few minutes.

A-grav is very energy efficient. To hold a ton of material hovering requires an energy consumption of only 1 kilowatt. There is only substantial energy consumption when gaining potential or kinetic energy using A-grav repulsion. To lift a ton of material to 180 kilometers from a planetary surface requires an energy expense of 500 kilowatt-hours of energy. This modest energy cost is easily supplied using TL9 atomic batteries. Once A-grav transport becomes feasible in a culture, all other forms of ground to orbit transport (e.g., beanstalks) become uneconomic.

A single TL9 gravity plate used in a hoverplate could levitate a mass of 5 tons over a typical planetary surface (specific gravity of 5) and would consume about 5 kilowatts (7 horsepower) of energy. A plate could also be used in an aircar to fly a 2.5 ton vehicle up to a elevation of 20 kilometers. The energy requirement here would be greater, due to the need to gain altitude and provide thrust, about 250 kilowatts (330 horsepower). The same plate could lift 0.5 to low orbit in 11 minutes at 1000 km/hour, and the power required would be 1360 kilowatts (1820 horsepower).

When descending or braking, the potential or kinetic energy loss is appears as heating of the A-grav plates. Using thermomagnedynamic couples, much of the energy can be reclaimed.

Another important use of A-grav is the production of surfaces that have a very strong repulsive field over a very short distance. The near-field effects allow the production of much stronger fields. A 1,000,000 g repulsive force can be produced over a distance of 1 millimeter from a surface. Such repulsive surfaces make possible the practical handling of antimatter in significant quantities. G-drive is made possible by A-grav technology. For near fields such as this, A-grav surfaces do not need to be flat. Even complex shapes can be produced, though they are costly at TL9. The reverse effect can be used to produce surfaces that grip tightly whatever touches them.

A-grav plates can be used to create force cages. A 5 g force wall one meter thick (the A-grav force directed horizontally toward the captive) could not be overcome by an unaided person. Would have an distinct advantage when confining additional persons: the field does not need to be turned off to add an additional captive, just push them into the confining field. It is gravitationally equivalent to dropping people into a pit.

A-grav can be used to create tractor beams. Stacked A-grav plates can create an effective grappling field. At TL10, small hand A-grav grapples (looking rather like flashlights) made of 50 small stacked plates are standard tools, particularly useful in zero gravity, capable of producing a 1-g field at a distance of 50 meters.

Using the small gravity plates available at TL10, personal flying units are easily produced. A 30 cm by 30 cm plate can lift 450 kilograms. Plate stacks can even be implanted within the bodies of individuals.

A-grav can also be used for gravitational detection and ranging (GRADAR). A gravity plate can detect a mass at a distance by noting the force produced when a mass is within its volume of effect. Gradar would not provide any knowledge of the nature of the object however, only its mass and position would be detectable. With sensitive instruments, it is possible to detect a spacecraft at up to 1,000,000 kilometers using this effect, even if the spacecraft were invisible in the electromagnetic spectrum. By producing canceling A-grav fields, a ship can make itself far less visible to gradar, reducing the detection distance to 1000 kilometers.

A-Grav based Personal Equipment

Weight	Item	Description	Price	TL
2 kg	A-Grapple	Flashlight sized grapple. Works up to 50 meters for a 1G narrow field	100cr	10
5 kg	Wingz	Combination A-Grav and flapping Ornithopter-type wings. Lifts 250kg at 1G, and moves at 20 KPH.	250cr	10
3kg	Hoverchair	A legless gliding chair which stays a fixed .5 meters above the ground.	50cr	10
1kg	Glides	Frictionless boots used for sports	50cr	10
10kg	Grav Pallet	Device for holding and moving objects massing up to one ton	50cr	9
1kg	Sticktite	Double surface A-Grav device for holding objects to a surface.	35cr	10
1kg	Stickyboots	A-Grav boots allowing one to walk in a zero-G environment	50cr	10

A-Grav based Ship Equipment- Tech Level 9

Item	Description	Cost	Tonnage	Skill Req'd
GRADAR	Gravitational Detection And Ranging sensory array. Operated through Scan Station.	1000cr	1 ton	N/A
AGC	Active GRADAR Countermeasure Emitters. Operated through Shield Station.	5000cr	1 ton	N/A
Forcecage	Device for immobilizing prisoners. Built into Brig cells.	100cr/cell	N/A	N/A