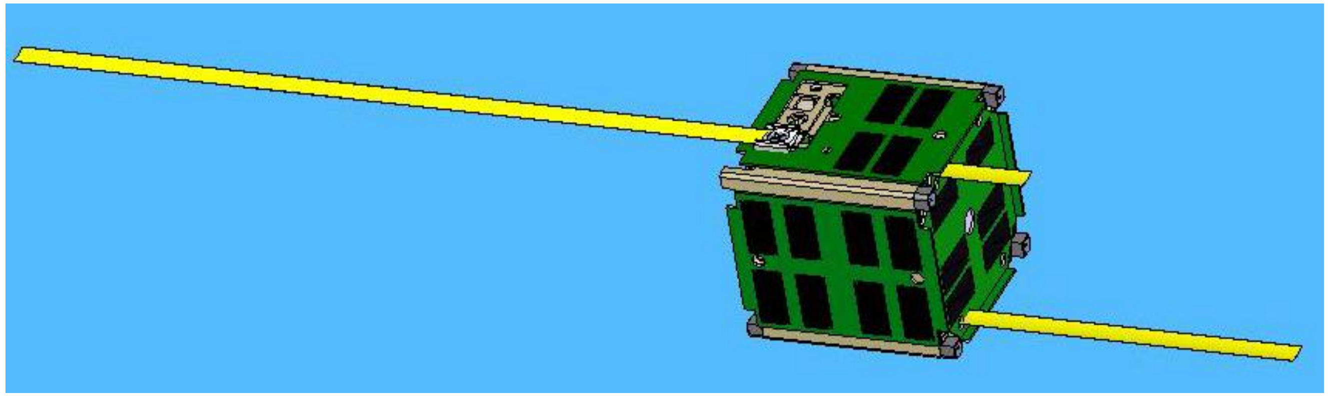
Magnetic Stabilization

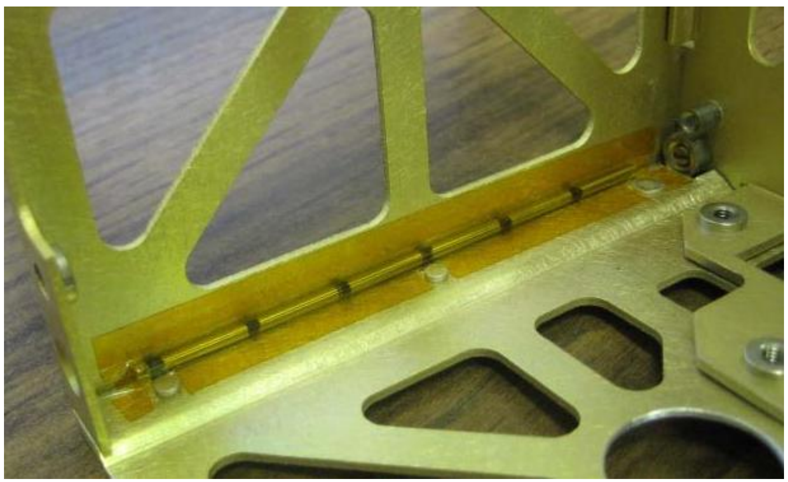
Magnetic stabilization is a method of SC stabilizing using geomagnetic field of the Earth

SC is positioned along the magnetic lines of the geomagnetic field ("magnetic compass")



KySat-1 Passive Magnetic Stabilization System is used for antenna orientation and coarse camera pointing

KySat-1, the first satellite project by Kentucky Space, is a 1-U CubeSat scheduled to launch in 2010 on a NASA mission.

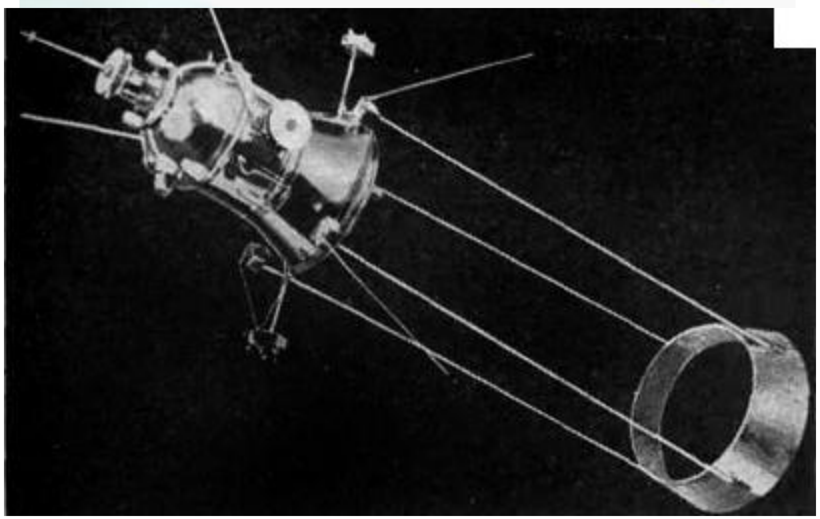


← One of Four Alinco-5 Permanent Magnet sets on board KySat-1.

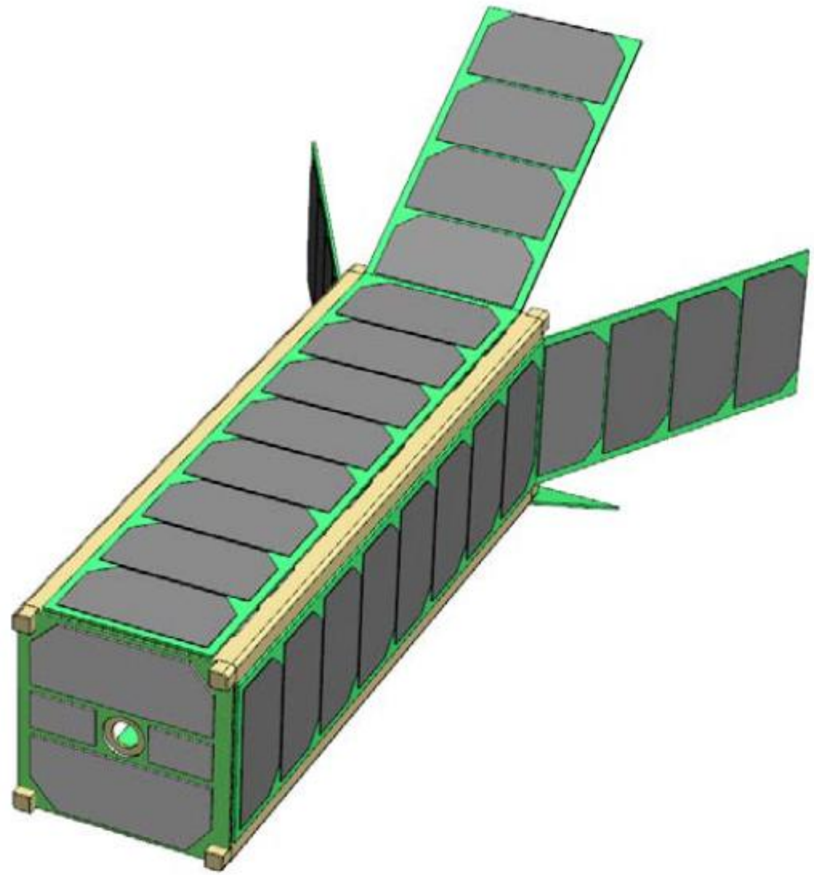
Aerodynamic Stabilization

The Aerodynamic stabilization is a method of SC stabilizing using aerodynamic force in rarefied atmosphere of low earth orbit .

SC is positioned along the orbital velocity vector



SC with tail unit



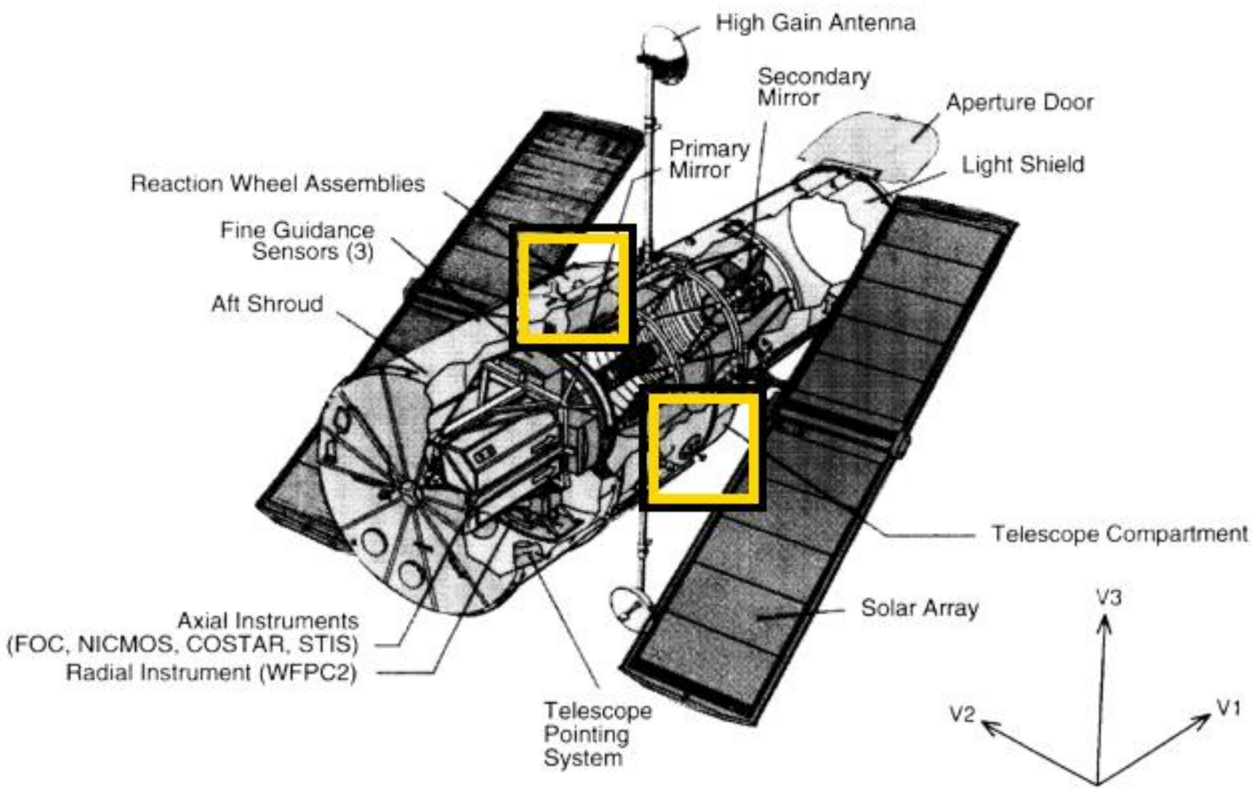
Aerodynamically Stable CubeSat Design Concept

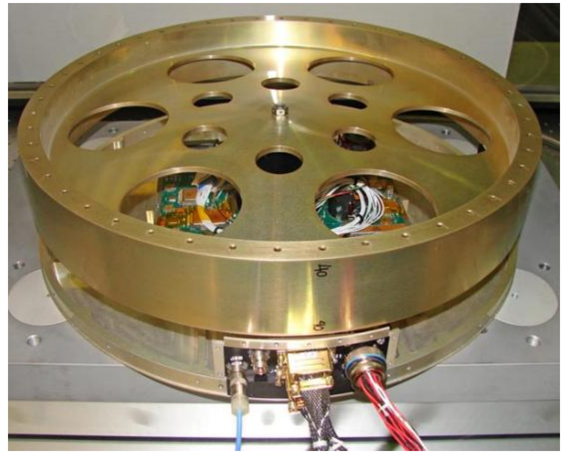
Actuators

Reaction Wheel Assemblies (RWAs)

RWAs are particularly useful when the spacecraft must be rotated by very small amounts, such as keeping a telescope pointed at a star.

This is accomplished by equipping the spacecraft with an electric motor attached to a **flywheel, which when rotated increasingly fast causes the spacecraft to spin the other way** in a proportional amount by conservation of angular momentum.

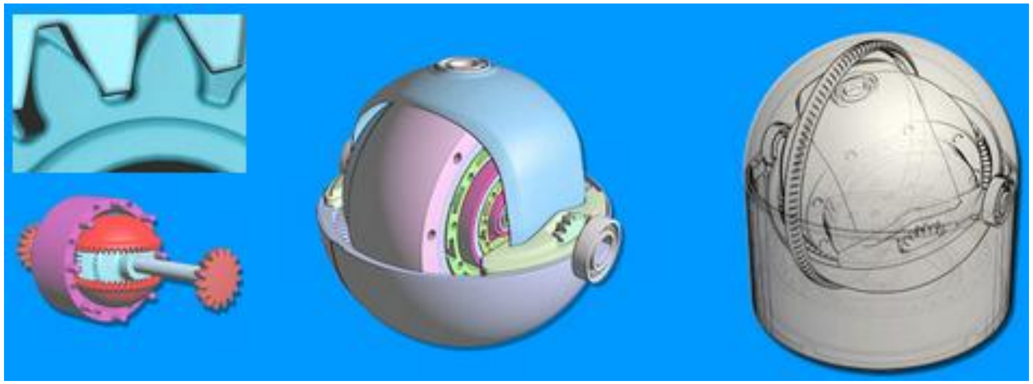


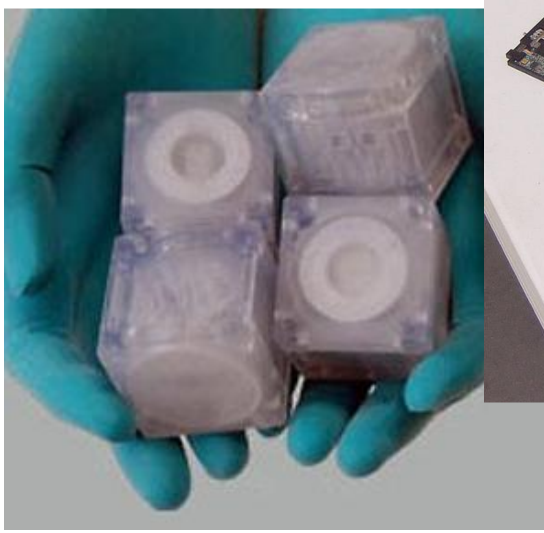


Actuators

Control Moment Gyros (CMGs)

A CMG consists of a spinning rotor and one or more motorized gimbals that tilt the rotor’s angular momentum. As the rotor tilts, the changing angular momentum causes a gyroscopic torque that rotates the spacecraft.





Microsatellite with four control moment gyroscopes

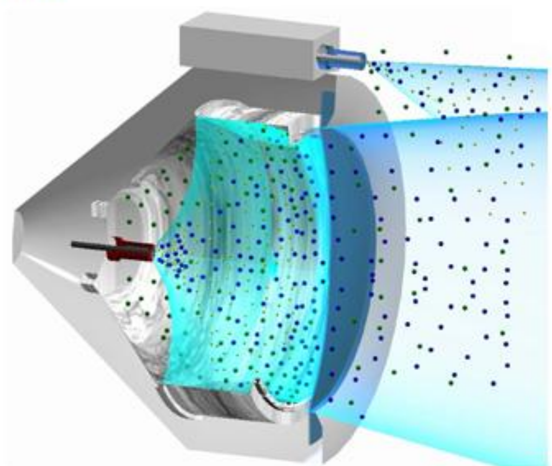
Actuators

Thrusters

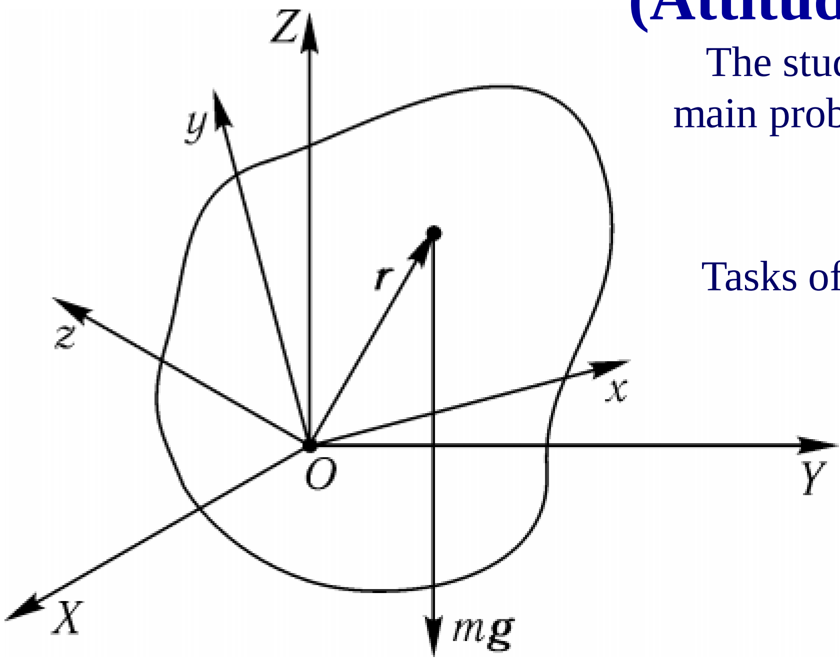
A **thruster** is a small propulsive device used by spacecraft for attitude control, in the reaction control system, or long-duration, low-thrust acceleration

Cyclone-3 LV thruster of 30 N thrust

Liquefied gases in high-pressure balloons



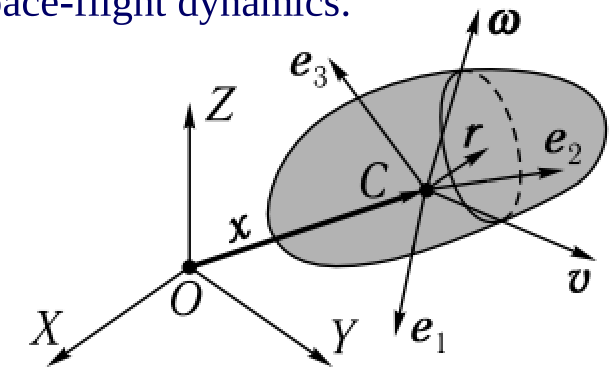
Main Equations of Angular Motion of Rigid Body (Attitude Motion of SC)

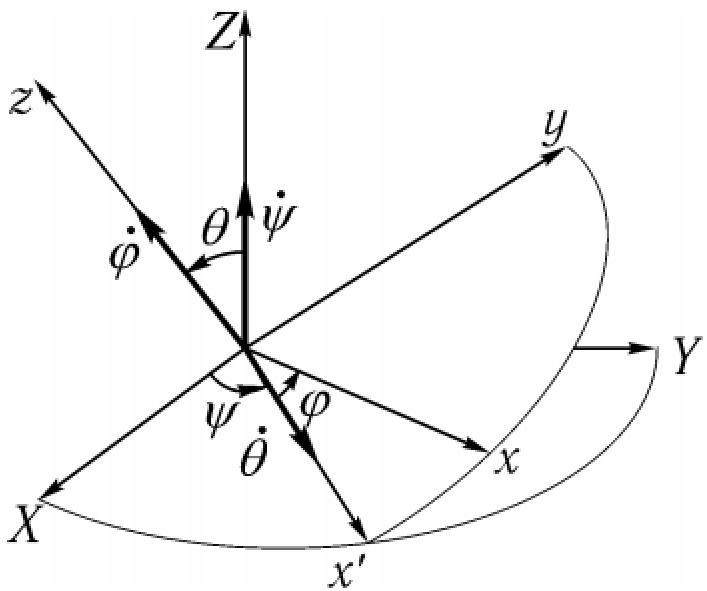


The study of the angular motion of the SC attitude dynamics is one of the main problems of rigid body systems dynamics in the classical mechanics.

And vice versa

Tasks of analysis and synthesis of the rigid bodies' motion have important applications in the space-flight dynamics.





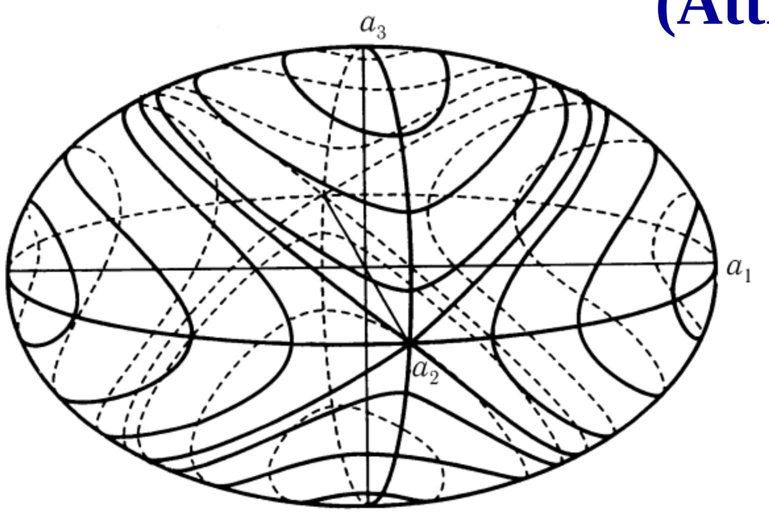
Euler dynamical equations:

$$\begin{cases} \mathbf{I}\dot{\boldsymbol{\omega}} + \boldsymbol{\omega} \times \mathbf{I}\boldsymbol{\omega} = \mu \boldsymbol{r} \times \boldsymbol{\gamma}, \\ \dot{\boldsymbol{\gamma}} = \boldsymbol{\gamma} \times \boldsymbol{\omega}, \end{cases}$$

Euler kinematical equations:

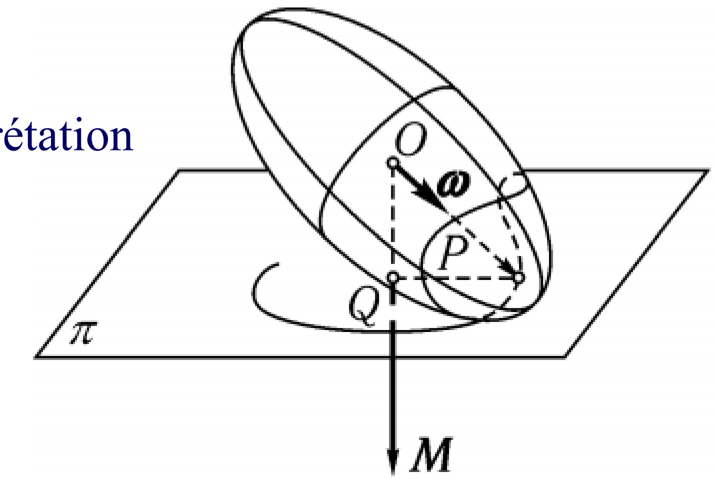
$$\omega_1 = \dot{\psi} \sin\theta \sin\varphi + \dot{\theta} \cos\varphi,$$
$$\omega_2 = \dot{\psi} \sin\theta \cos\varphi - \dot{\theta} \sin\varphi,$$
$$\omega_3 = \dot{\psi} \cos\theta + \dot{\varphi}.$$

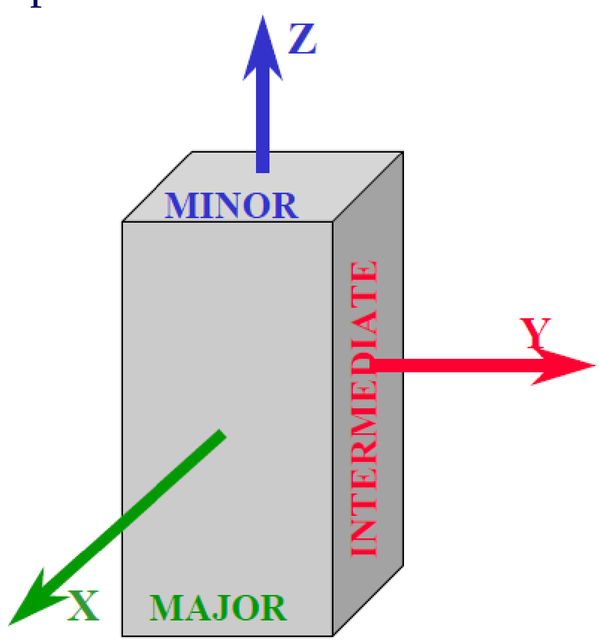
Main Properties of the Free Angular Motion of Rigid Body (Attitude Motion of SC)



Inertia tensor with polhodes

Louis Poinsot interprétation

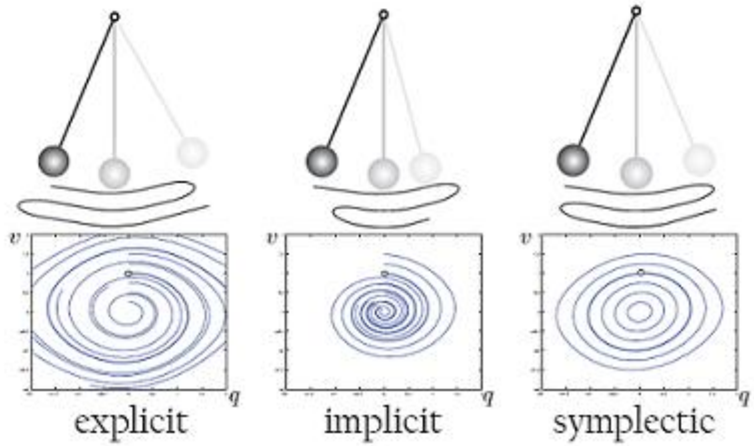


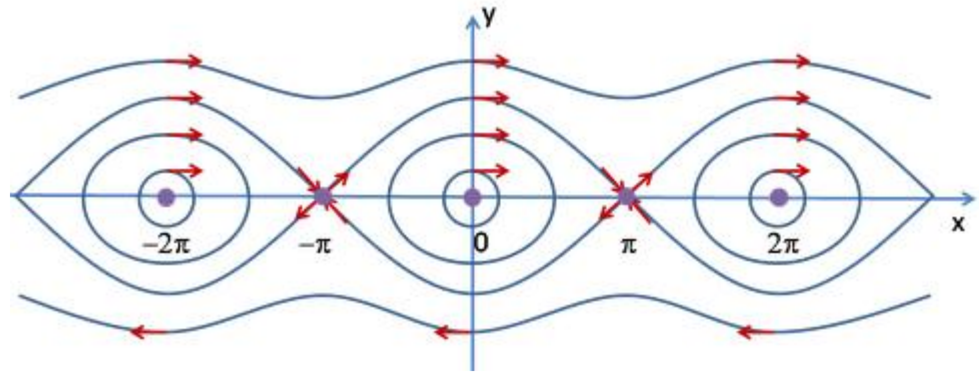


- $I_{xx} > I_{yy} > I_{zz}$
- Major axis spin is stable
- Minor axis spin is stable
- Intermediate axis spin is unstable
- Energy dissipation changes these results
  → Minor axis spin becomes unstable
- This is called the Major-Axis Rule

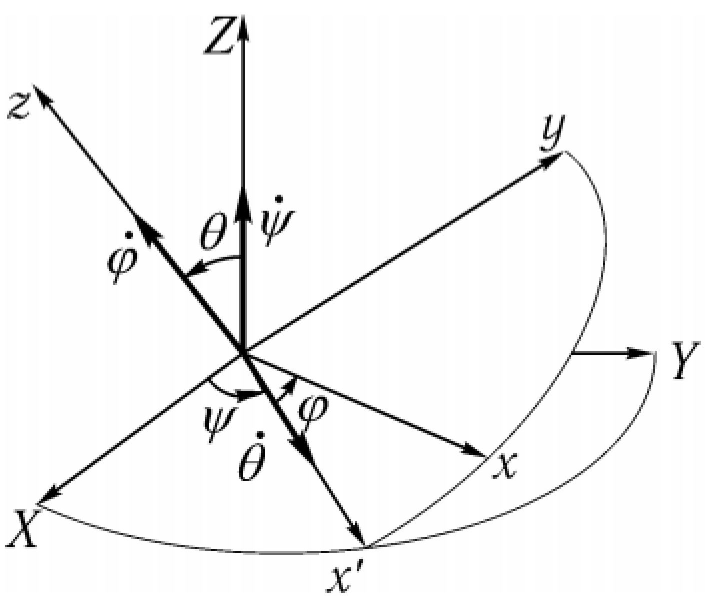
--- notation by C.D.Hall

Main Properties of the Free Angular Motion of Rigid Body (Attitude Motion of SC)





Pendulum phase space



If we consider rigid body angular motion on the base of Hamilton dynamics, than for rigid body motion we take pendulum phase structure:

x=tetta (nutation)

and

y = impulse (tetta) ~ d(tetta)/dt

Conclusion

The main properties of the attitude stabilization and control of SC (and multirotor systems) have been examined.

Research into attitude motion of the one-body-SC, dual-spin SC and spider-type-SC is very complicated.

Nontrivial and chaotic modes are possible in the SC attitude motion.