Chapter 1

Introduction

1.1 Historical Review of Solar System Formation

The theory of solar system formation has been developed long time ago since the planet was observed. The more scientific theory, however, was established after Laplace had proposed his Nebular Hypothesis in 1796. The development and the proposal of solar system theory have been going on.

In general, the theory of the solar system formation can be classified into three kinds: monistic, dualistic, and pluralistic. Monistic theory believes that the solar system was evolved from one huge cloud of gas and dust, called nebula, through the gradual process of collapse. Dualistic theory believes that the solar system was originated from the strong interactions between two objects such as the Sun and the passing star or passing nebula. Pluralistic theory seems to be the combination of both former theories: the original system was a cluster that can be collapsed gradually by its own gravity (Monistic) and every cloud in cluster can be interacted each other to form the denser objects (Dualistic). A brief history of the solar system formation theories is presented as follows.

The Cartesian Hypothesis (1644) *(Monistic)*

Rene Descartes (1596-1650), the French philosopher, proposed in his "Principia of Philosophy" that the circular eddies, called vortices, were formed in a primordial gas cloud and eventually settled down to become all planets. This hypothesis was later disproved by Newton. (ICR, 1992)

Swedenborg's Nebula Hypothesis (1734) *(Monistic)*

Emmanuel Swedenborg (1688-1772) theorized spiritually in his book, Principia, that a rapidly rotating nebula formed itself into our solar system. (ICR, 1992)

Kant's Nebula Hypothesis (1766) *(Monistic)*

Immanuel Kant (1724-1804), the German philosopher, suggested that a swirling cloud of gas were formed themselves into the Sun and planets; this hypothesis was influenced by Swedenborg's nebular hypothesis. (ICR, 1992)

Buffon's Collision Hypothesis (1779) *(Dualistic)*

Georges Louis Leclerc Comte de Buffon (1707-1788), the well-known French naturalist, wrote in his "Epochs of Nature" that the Earth was formed from material torn out of the sun by a passing comet.

Buffon's theory was false after the facts of comet had been revealed; it is very small compared with the Sun or even the Earth, so it could not bring anything from the Sun. (ICR, 1992)

Laplace's Nebula Theory (1796) *(Monistic)*

Marquis Pierre Simon de Laplace (1749-1827), the French mathematician, postulated that the Sun and the planets were formed from a spinning cloud of gas called nebula. As this cloud collapsed, it would rotate faster in a certain direction to conserve the angular momentum. The cloud became flat like a disk belongs to a plane of rotation. The spinning disk cloud supposedly threw off the gas rings that eventually condensed to form the planets. The rest of nebula collapsed further to form the sun at the center. (ICR, 1992)

Laplace did not proof that his hypothesis was correct. Then, some of the details of his theory were later though for a time to be impossible; for example, it was calculated by the great British physicist James Clerk Maxwell that the gaseous rings could not collapse to form planets and moon or any objects (Pasachoff, 1984).

Moreover, this hypothesis cannot explain why the Sun spins slowly in spite of the nebula spun faster as it collapsed; this problem is known as *the angular momentum problem of the Sun.*

Jeans Tidal Theory (1917) *(Dualistic)*

Sir James Jeans (1877-1946) suggested that a passing star drew the hot gaseous material out of the Sun as a filament by tidal effect. The filament then cooled down and broke up to form planets. Although this theory had been supported by some elegant analysis, the objections still made. For example, Henry Norris Russell (1935) shown that the filament drawn from the Sun could not be longer than four solar radii, Lyman Spitzer (1939) calculated that a Jupiter mass of hot material, temperature about 10^6 K, would explode into space rather than collapse, etc (Stephen, 1999). The tidal theory is now out of fashion (Woolfson, 2000).

Weizacker's Vortex Theory (1944) *(Monistic)*

Carl F. von Weizacker, the German scientist, presented a new kind of Nebula Theory; his nebula was not formed the rings as Laplace's nebula. The planets were formed from the turbulence of material in a disk in the form of eddies between vortex rings. The problem of this theory is the material in eddy may not condense because their relative velocity is very high. This theory, however, has been interested until nowadays. (ICR, 1992)

McCrea's Protoplanet Theory (1960) *(Pluralistic)*

William H. McCrea (1904-1999), suggested that the solar system is the product of a stellar cluster. In cluster, the turbulence of gas streams would induce the high-density regions called floccules. Each floccule moved through the cloud together with accumulating their mass. The Sun was formed by random collision of many floccules. Some floccules grew larger to form protoplanet, which then fragmented to form planet and satellites. This theory can explain quite well about the slow spin of the Sun and the spin direction of planets (Woolfson, 2000).

Woolfson's Capture Theory (1964)

Woolfson proposed a kind of Tidal Theory that the Sun captured some of mass of a passing protostar as a filament, which later fragmented to form planets. This theory is the reversing of Tidal Theory with a cooler passing object (Stephen, 1999).

All theories described above still being incomplete to explain the solar system formation. The contemporary theories tend to look up to a kind of Nebula Theory, for example, the Solar Nebula Theory and the Modern Laplacian Theory (Woolfson, 2000); both theories try to account for the angular momentum problem of the Sun.

1.2 Gross Features of the Solar System

Solar system has many wonderful features that challenge all theories to account for. Those main features are summarized as follows.

- All planets revolve in the same direction, counterclockwise, as the rotation of the Sun.
- The orbital planes of all planets are approximately the same except Pluto.
- All planets, except Mercury and Pluto, orbit in nearly circular.
- Most planets rotate in the prograde direction, counterclockwise, as their revolving direction while Venus and Uranus are retrograde.
- There are two kinds of planets: terrestrial planets (Mercury, Venus, Earth, and Mars) and jovian planets (Jupiter, Saturn, Uranus, and Neptune). Terrestrial are small, high density, low mass, more heavy elements, rocky surface, thin atmosphere, and high temperature. Jovian are large, low density, more massive, abundant with light elements, gaseous surface, thick atmosphere, and low temperature.

- The mass of the Sun is approximately about 99.86% of solar mass but 99.5% of angular momentum contain in planets. This problem is known as the angular momentum problem of the Sun (Stephen, 1999).

- There are numerous small rocky objects in the solar system, most of which lie in a gap between the orbit of Mars and Jupiter, called the asteroid belt.

- Most satellites of jovian planets revolve approximately in the same plane of their planet's equator.

- Some outermost satellites of jovian planets are retrograde.

- Our galaxy is retrograde relative to the rotation of solar system.

These features are the basic requirements of the theory of solar system formation; a good theory should explain all or most of them.

1.3 Purpose and Scope of this Work

The purpose of this work is to construct the model that explains how the solar system forms and fits most features mentioned in Section 1.2. This model is based on four mechanical interactions of particles that can be simulated. The evolution of the solar system is described by comparing with the simulation results and determining from some mathematical methods.

Although the present day theories of solar system formation are more advanced, the simple model of this work can be constructed by neglected some complicated factors such as the effects of magnetic field, heat and turbulence (Larson, 2003). The scope of this master thesis, however, is mainly limited by the condition of time and the complexity of simulations, more complexity more computer speed needed. Furthermore, this model still being hypothetical in nature in this work because the calculation of certain characteristic values (for example, mass, density and size) of the real system is not yet established.