PROCEEDINGS OF SCIENCE

Historical Novae and Supernovae

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Historical discoveries and records of novae and supernovae are reviewed that were performed in the east Asian countries. Among them, Korean official observational records in 11th century are of great importance because of their precise positional data. In addition, some of the historical novae and supernovae are possibly recorded in the Antarctic ice core in the form of nitrate ion (NO_3^-) concentrations produced by gamma ray originated from star explosions.

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1. Introduction

Modern astronomy is basically upon the development in the western world .However, before the Supernova AD 1572 examined by Tycho Brahe, such spontaneous and transient phenomena as "New Stars "were not seriously recorded or ignored due to Aristotelian concept of the sky("The Sky is to be eternal") that is dominant over the western world.On the contrary,east Asian countries,free from the constraint of the Aristotelian philosophy, mainly in ancient Chinese dynasties, Korean peninsula and Japan, such phenomena were observed and recorded systematically as the so-called "Guest Stars" including both novae and supernovae.After Tycho,up to middle 19th century,the new stars(Nova Stella) and other variable stars were recorded by both professional and amateur astronomers including John Flamsteed(The first Astronomer Royal).

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2. Data base of the "Historical Novae and Supernovae"

In this half a century there appeared several data base and monographs concerning the discovery of "nova".One of th most important ones are written by Cecilia Payne-Gaposchkin(1957).At that time,however,the notion of the cataclysmic variable star was not yet established. After 1970s ,as a result of the observational and theoretical study of the close binary star systems,the classical novae and recurrent novae are taken as one category of the close binary system containing compact (mainly white dwarfs) components.Also the nature of the accretion disk that plays an essential role for nova-explosion. The most complete and reliable data base are the article by Duerbeck (2008) for Galactic novae and the monograph by Stephenson and Green(2004) for Galactic supernova and supernova-remnants. Selected star lists are in Table 1. This report is mainly based on these two works.Here the word "historical" is mainly the pre-telescopic discovery of the "New" stars.

3. Historical Novae

The article by H.Duerbeck (2008) is the most comprehensive data base for historical Galactic novae.There appear 30 candidate stars for novae and supernovae which were called as "Guest Stars".The meaning of this term is transient or spontaneous. Several concerning objects are listed in Table 1.Here source A,C,E ,J and K are Arab,China,Europe,Japan and Korea,respectively. Type k'o means guest star.RA and Decl are at equinox(epoch) 1950.0. Additional notes is given by the present author.

4. Historical Supernovae

Stephenson and Green had been studying both historical Galactic supernovae and supernova-remnants.Their monograph published in 2004 is an excellent work.They treated and examined the historical Galactic supernovae and also suspected ones. More than 300 Galactic supernovae and supernova remnants are listed.Among them,the suspected supernova 1680 observed by John Flamsteed, is described .This is the object that Flamsteed ,the first Astronomer Royal,erased his observation soon .However a supernova-remnant exists close to the position and year corresponding

Table 1. A Catalogue of Selected Pre-telescopic Galactic Novae and Supernovae.
* A:Arab, C:China,E:Europe, K:Korea, J:Japan ** k'o= Guest Star

Date	Source*	Type**	RA	Decl	Note	Additional notes
3/April/1006	ACEJ	k'o	15 10	-40	SN	Meigetsuki
4/July/1054	CJ	k'o	05 40	+20	SN	Meigetsuki
9/Oct/1073	K	k'o	00 10	+05	–	R Aquarii (?)
19/Aug/1074	K	k'o	00 10	+05	–	R Aquarii(?)
8/Nov/1572	CEK	k'o	00 20	+65	SN	Tycho
8/Oct/1604	CEK	k'o	17 30	-20	SN	Kepler

Table 2.Selected SNRs.

l(deg.))	*b*(deg.)	R.A(h m s)	Decl(deg min).	Name	Other Name	Notes
4.5	+6.8	17 30 42	-21 29	Kepler	SN1604	3C158
111.7	-2.1	23 23 26	+58 48	Flamsteed?	Casiopeia A	3C461
120.1	+1.4	00 25 18	+64 09	Tycho	SN1572	3C10
184.6	-5.8	05 34 31	+22 01	Crab Nebula	SN1054	3C144
327.6	+14.6	15 02 50	-41 56	–	SN1006	PKS 1459-41

Flamsteed 's observation .This remnant is located at *b*=-2.1 arc degree on the plane of the Milky Way in Cassiopeia.So the brightness is thought to be strongly diminished due to atmospheric distinction and disappeared soon after maximum.

A selected SNRs are listed in Table 2.

5. Korean record of Guest Star

In 2005,a Korean astronomer Hong-jin Yang proved that the AD 1073 and AD 1074 guest stars are identical to the symbiotic star R Aquarii . Korean astronomers at that time possessed their own sky chart which is far different from the western ones but good enough for identification (fig.1.This is presented by H.-J.Yang to me).

In fig.2,Hong-Jin Yang and his co-authors identified the 1073 and 1074 Guest Stars are identical with the same star and is the symbiotic star R Aquarii (Fig.2).

6. Ice core records due to supernova explosion

Rood(1979) proposed that nitrate ion (NO_3^-) concentrations are to be detected in the Antarctic ice core due to gamma ray generated by the historical galactic supernova-explosion.The nitrate ion production mechanism is thought as follows:such ions are produced by the high energy ($\gtrsim$ 40 KeV) photon where the photoelectric effect is dominant (see ,for example ,Ramana Murthey and Wolfendale (1993),Longair (2011)).Such photons hit the nitrogen atoms of the stratosphere to highly

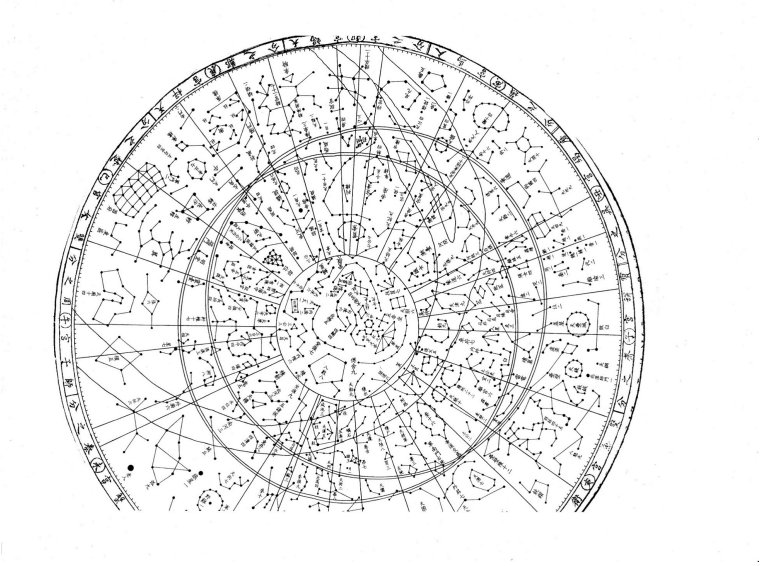

Figure 1: Korean sky map.By the courtesy of Dr.Hong-jin Yang.

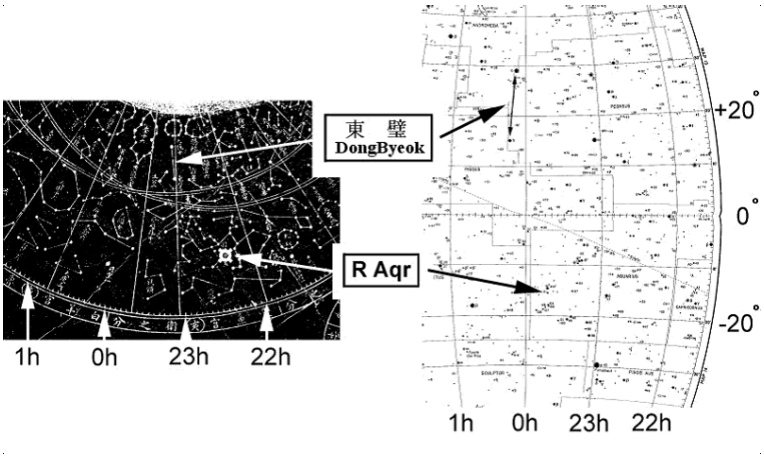

Figure 2: Position of the Guest Star AD 1073 and 1074.(From Hon-jin Yang et al 2005)

excited or ionized nitrogen(N^+) states.On the other hand,solar UV produces ozone(O_3).These two combine together to yield nitrate ions ($NO_3{}^-$).Then these ions are thought to be confined and frozen in the Antarctic(and Arctic) ice core.However such type of ion concentrations are occasionally be contaminated by the big volcano-explosions.

7. A Depth-Age Relation and a tentative application to the Historical Novae and Supernovae

The nitrate ion concentrations in the Antarctic ice core extracted from the Japanese Dome Fuji Station(3810m height) is used for our purpose of obtaining the Depth-Age relation.

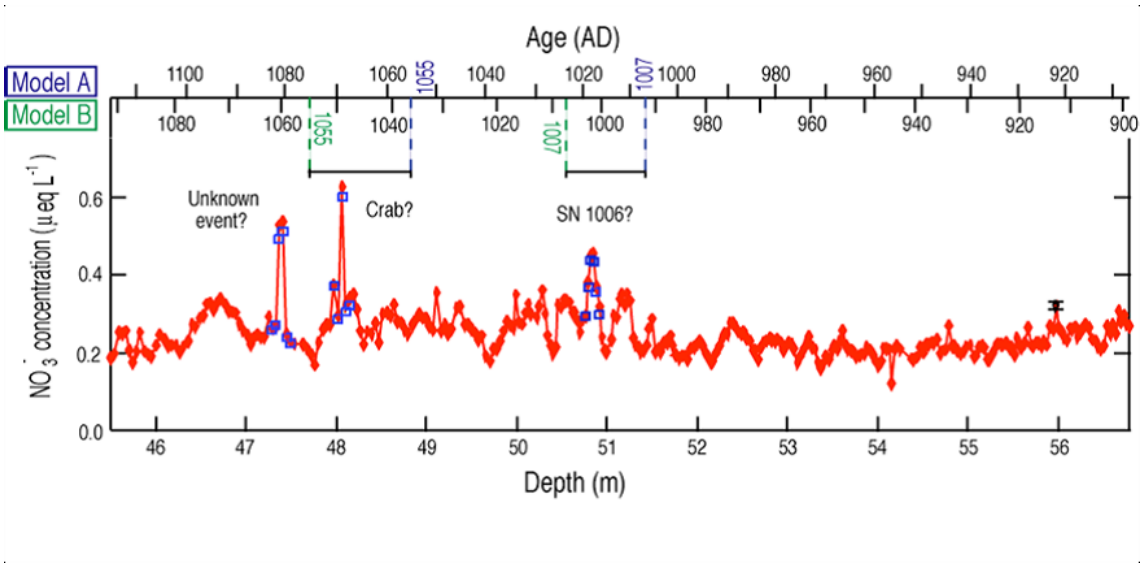

Figure 3: Antarctic (Dome Fuji) ice core data

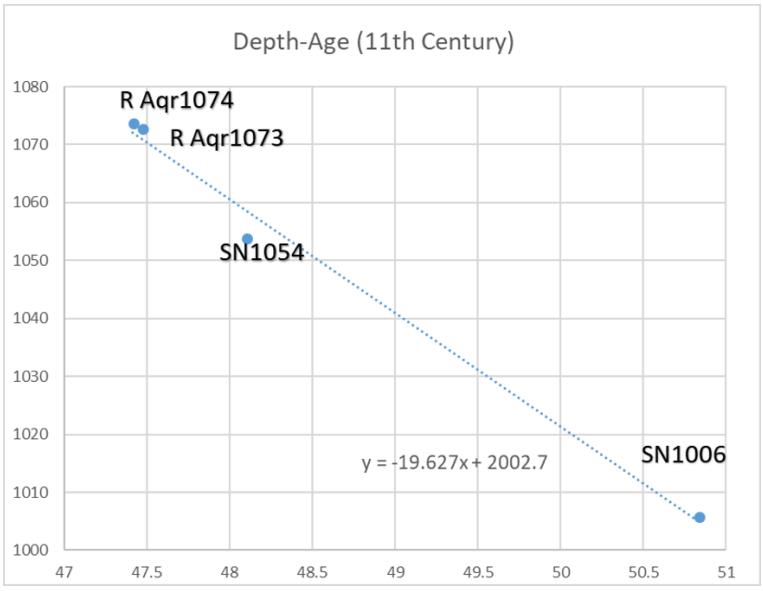

Figure 4: A tentative Depth-Age relation in 11th century.

7.1 Depth-Age relation of 11th century Ice-core records

From the depth data,

AD 1006 x=50.83 m

AD 1054 x=48.10 m

AD 1073 x=47.47 m

AD 1074 x=47.41 m

Accordingly,between depth x and age y the following tentative relation is obtained ,using linear regression:

$$y = a + b * x$$

where $a = 2003 \pm 67$ and $b = 19.6 \pm 1.3$

The value of a is close to the year (2001) of drilling the ice core.Therefore the assumption of linear regression is adequate for depth-age relation.

7.2 Application of the depth-age relation to 16/17th century ice core records

In the Dome Fuji ice core,nitrate ion concentrations(spikes) at the depth of 15 m to 20 m are thought to be around 17 century. There exist 4 conspicuous spikes A,B,C and D (See,Tanabe and Motizuki(2018))in which the following depth (x) can be seen (these depth values are preliminary ones,and will be revised in the near future.) :

A : x=21.7 m

B : x=19.6 m

C : x=17.8 m

D : x=15.6 m

Applying the above obtained Depth-Age relation,the age of each spike is as follows:

A:1547 - 1603 (including 1572;Tycho's Supernova ?)

B:1591 - 1642 (including 1604;Kepler's Supernova?)

C:1628 - 1675 (No possible stellar eruption is recorded so far.)

D: 1674 - 1715 (including 1680; Flamsteed's missing Supernova?)

Overall Diagram is shown in figure 5.

8. Concluding Remarks.

1. Most of the pre-telescopic discoveries and records on Novae and Supernovae are seen in Asian official documents.

2. Among them Korean historical "Guest Star" records are thought to be of great importance because of their positional informations.

3. Using the 11th century ice core records of Japanese Antarctic station, taking into account the Korean records ,a reasonable linear Depth-Age relation is obtained.

4. Applying the above obtained relation,3 of 4 conspicuous spikes are possible historical supernovae.

5. Unknown spike C is possibly due to a big eruption of volcano(Mount Vesuvius(1631),for example, ?).

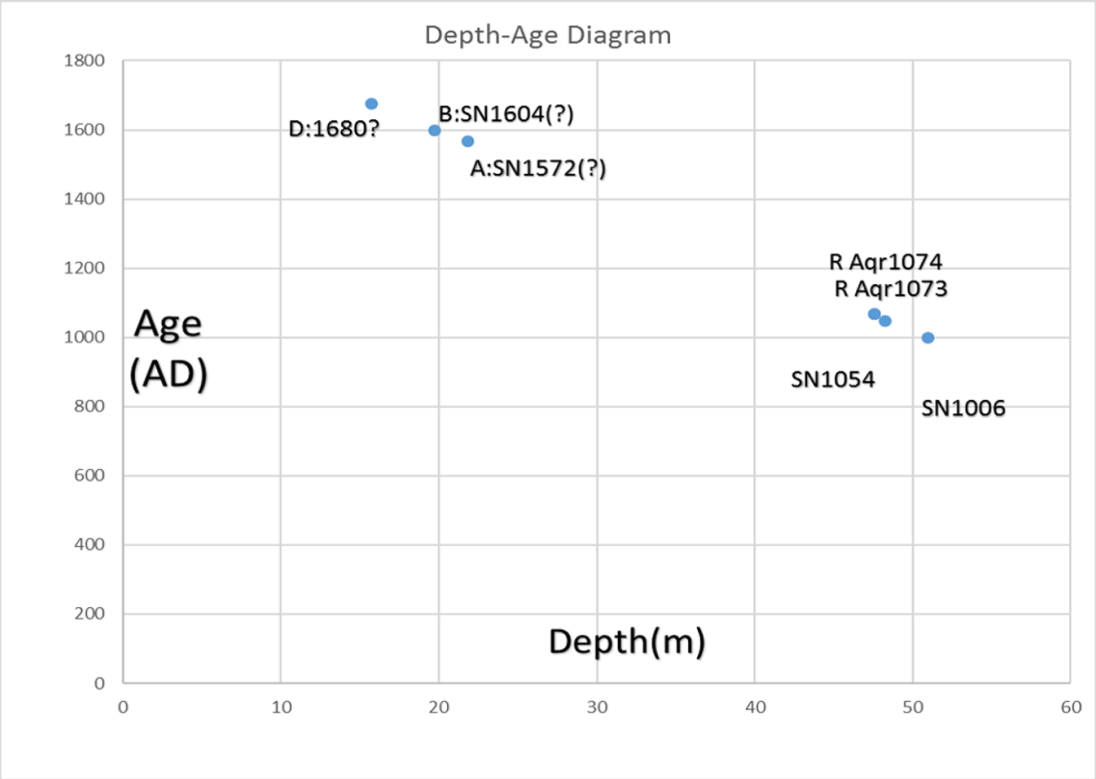

Figure 5: Depth-Age relation from 11century to 16 and 17th century.

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