Mem. S.A.It. Vol. 83, 840

Memorie della

Symbiotic nova eruption of R Aquarii

A geological remnant?

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Abstract. An evidence of possible nova eruption of the symbiotic star R Aquarii, which was recorded in the historical books by ancient Korean astronomers, is discovered in an antarctic ice core as a nitrate ion concentration (spikes) .These spikes , separated by only one year,are as prominent as other spikes of the recorded supernovae in 11th century .These set of two spikes do not coincide with any supernova remnants but successfully coincide with the nova eruption of R Aquarii in the year of A.D. 1073 and A.D.1074 in the Korean historical records.

Key words. Nova: symbiotic star – Nova: historical records – Nova: antarctic ice core records

1. Introduction

One of the oldest known symbiotic star R Aquarii is a quite mysterious one.It was originally discovered as an Mira-type variable star,and afterwards found to be a symbiotic binary star consisted of a giant and white dwarf.The star shows Mira type long period pulsation though,the optical amplitude is smaller than ordinary Miras. In 2005,Hong-Jin Yang et al. reported the details of R Aquarii's eruption in A.D.1073 and A.D.1074,based on the Korean historical official books,which describe a precise position corresponds to R Aquarii.The record also describes its maximum brightness.

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On the other hands, since the end of 1970s, attempts have been done to search for the supernovae remnants corresponding to the antarctic and arctic ice core records.These records are nitrate ion (NO_3^-) produced by the gamma ray radiated from galactic supernova explosion.At first sight such attempts seemed to be promising.However there existed various difficulties,mainly concerning the methods of treating and processing the drilled ice cores.

Recently Japanese team of antarctic ice core research had chosen a suitable place for supernovae remnant search.In the drilled samples there exists a part having 11th century record which is thought to be the best ones for the purpose of supernova record investigation.The reason is that in this century there existed comparatively less geological(volcano eruption and other meteor logical effects) .Several nitrate ion spikes(ion concentration) are discovered corresponding SN1006 and SN 1054.In addition there exists one set of two spikes that does not coincides any known supernova record. These spikes are separated only one year.The author's idea is that these are probably due not to supernovae but to nova(symbiotic nova?) eruption of R Aquarii which had been recorded by Korean ancient astronomers.The aim of this paper is to show the relation between the Korean records on R Aquarii and recently obtained antarctic ice core records.

2. R Aquarii as a candidate of symbiotic nova

2.1. Properties of R Aquarii

The oldest known symbiotic star R Aquarii is one of the brightest(naked eye visible) variable star.However this star is a quite mysterious and enigmatic variables.As a Mira-type variable,the optical amplitude shows much smaller magnitude range(5.8-11) compared with its pulsation period (387 days).Also its orbital period is not yet known (44 years is proposed).Moreover it had been showing high and low state in its activity.The reason of it is thought to be its eccentricity of the binary orbit.In addition , the star accompanies nebulosity probably due to nova explosion. R Aquarii's basic properties are as follows (mainly from Kenyon, 1986):

1. Symbiotic star(D type)
2. Accompanying nebulosities due to outbursts whose extension is 2 arcmin.
3. Position:(α, δ)=(23h44m,-15deg 17min) , (l, b)=(66.5,-70.3)
4. Magnitude range:5.8-11;abnormally small amplitude!
5. Period of Mira-pulsation:386.83day
6. Spectral typeFM5-M8.5
7. Binary properties: orbital period unknown,(44years ?),separation unknown
8. Distance: unknown

2.2. general properties of symbiotic novae

To determine whether R Aquarii experienced true symbiotic nova eruption or not , it is necessary to summarize the general properties of of the symbiotic novae(Kenyon 1986,Warner 1995). There exist several (less than 10) symbiotic novae.The definition of this type and properties are as follows:

1. A symbiotic star once experienced nova eruption.
2. Not very slow nova but "extraordinary slow nova h
3. Following 10 (or more?) symbiotic novae are known:
   V1016 Cyg,V1329 Cyg,V2110 Oph, AG Peg, HM Sge, RT Ser, RR Tel, PU Vul, FG Ser,PG Ser,AS 338
   (Recent nova eruption of symbiotic star V407 Cyg is not a symbiotic nova.At that time gamma ray was detected by Fermi LAT satellite).

It is not widely accepted but many of their behavior in quiescence are suspected to be that of Mira-type variables.

3. Korean historical records of guest stars

As is well known,in Asian countries there exist various historical records on astronomical events ,mainly in China,Korea and Japan.One of the example is SN1054 existed in Japan.However Korean records are thought to be much more abundant and systematic than others. It is said that approximately 2,000 year official and systematic records exists. Among these historical books, Hong-Jin Yang et a. (2005) pointed out that a description on a guest star("Nova Stella") records in A.D.1073 and A.D.1074 corresponds to R Aquarii . (Also Duerbeck(2008) write a description on these two years but without any star identification.) The most interesting fact is a description of its precise position. The position of the guest star is exactly that of R Aquarii! (See the Figure 2 of Hon-Jin Yang et a.s paper, 2005).

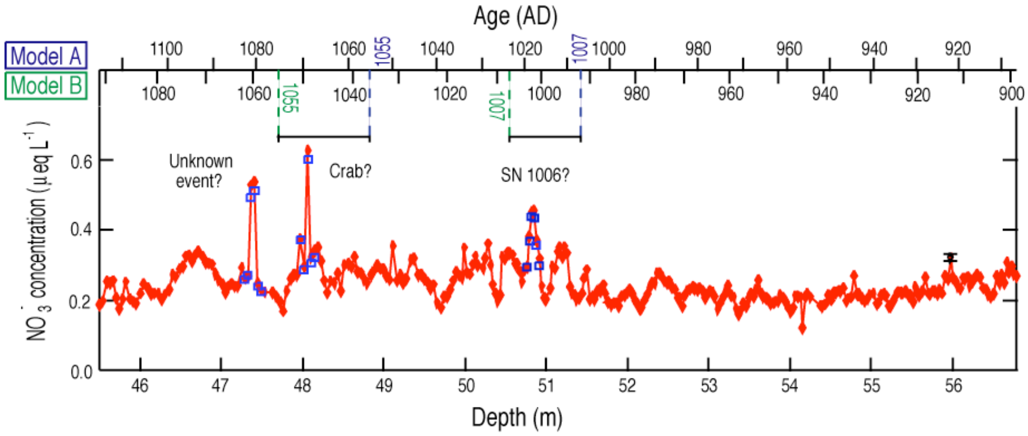

Fig. 1. Nitrate ion spikes in 11th century(from Motizuki et al.2009). There exist three prominent groups of nitrate ion spikes,earlier two are SN1006 and SN1054,but last group consist of two close spikes separated by one year had been unknown.However these "unknown event?" are possible records of R Aquarii in A.D.1073 and A.D.1074 because this group locates between A.D.1060 and A.D.1080.

In addition to this,a expression of its brightness(like "Orangeh!)can be a clue to its maximum brightness.Hon-Jin Yang et al.'s estimation of its apparent magnitude is -5~ -6mag.

4. Evidence for nova eruption of R Aquarii in the Antarctic Ice Core

4.1. Supernovae remnant search as a counterparts of ice core records

Arctic and/or antarctic ice core is thought to be possible records of past climate and other geological events.Such records have relative time resolution of smaller than one year(~0.7 year). However absolute time resolution is longer than relative one.One of the best way of absolute age determination is 11 year solar cycle combined with some geological events(volcano eruptions).

In 1979,Rood et al.suggested the relation of antarctic (south pole) ice records and supernova remnants.Their results contain several historical supernovae including SN1574 and so on.However subsequent research by different authors using ice cores from different places did not support the results.

4.2. Fuji ice core and nitrate spikes in the 11th century ice core

Since the end of last century,National Institute for Polar Research of Japan had started working in Antarctica,constructing several stations for geological and meteorological research.The most newly built station is named as Fuji Dome Station.This is located far from ocean and distant from the south pole.This station was chosen for the sake of least effects from the sea. Fuji Dome station's temperature is -58,its altitude is 3810m(approximately the same hight of Mt.Fuji). As is seen this station is an ideal choice for astronomical record. The original purpose of the ice core drilling is not for supernovae or other kind of star explosion , but for paleoclimate and other environmental research. However this station is thought to be one of the best place for drilling because of minimizing geological effects such as ocean , volcano and so on.

4.3. Nitrate ion spikes as the records of supernova explosion

As is known supernova explosion produces various kind of nucleus . Such isotope radiates gamma ray emission and arrive at earth atmosphere and finally produce nitrate (NO_3^-) ion . When this ions fall on antarctic ice , these ions will be fixed and compiled .

4.4. 11th century ice core record from Fuji Dome Station

Motizuki et al.reported a rather preliminary result by analyzing the Fuji Dome ice core.Fig.1 is the result.Three set of prominent spike are seen.Among them ,earlier two are possible record of known supernovae ,but the third group between A.D.1060 and A.D.1080 has no supernova remnant. However, according to the Korean historical book,A.D.1073 and A.D.1074 guest star is quite plausible for the ice core records.Moreover the star was thought to be brighter than ,say,Jupiter.The strongest evidence is that both the ice core record and historicakl ones have the the same (∼ one year) separetion.

5. Conclusions

We have obtained the following conclusion:

1. Korean guest star records of R Aquarii on A.D.1073 and A.D.1074 eruptions seems to be successfully supported by antarctic ice core records from both positional and photometrich points of view. Especially,
2. A set of the two spikes corresponds to the historically recorded of two outbursts.

Problems to be solved are as follows:

1. Can we obtain the relation of spike length and optical brightness ?
2. What is the process of nitrate ion formation due to gamma ray produced by nova eruption?
3. Is this eruption of R Aquarii a true symbiotic nova?

Acknowledgements. One of the author(K.Tanabe) express gratitude to Kazuyoshi Imamura for preparing manuscript.

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