Analysis of Korean Historical Astronomical Records

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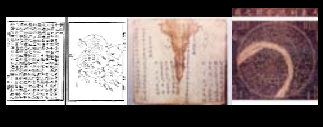
Korean Historical Astronomy

- Astronomical Almanac

- Observatories & Observational Instruments

- Books & Records



Korean Chronicles & Astronomical Records

KOREA (57 B.C.~A.D.1910)

- Samguksagi (57B.C.~A.D.935) : ~ 236 records
  (三國史記, the history of the Three Kingdoms)
- Goryeosa (A.D.918~1392) : ~ 5,000 records
  (高麗史, the history of Goryeo dynasty)
- Joseonwangjosillok (A.D.1392~1910) : ~ 20,000 records
  (朝鮮王朝實錄, the annals of the Joseon dynasty)

CHINA

- General Compilation of Chinese Ancient Astronomical Records
  (中國天象記錄總集 1988)

JAPAN

- Japanese Ancient Astronomica
  (日本天文史料 1935)
- Inventory of Japanese Ancient
  (日本天文史料總覽 1936)
- Japanese Ancient Astronomica
  (近世日本天文史料 1994)

Historical Astronomical Records

❑ **Books** : 三國史記, 高麗史(天文志, 五行志), 高麗史節要, 朝鮮王朝實錄, 增補文獻備考(象緯考), 星變測候單子, etc.

❑ **Classification**

- Sun & Moon : 日(月)食, 日中有黑子, 日(月)色-, 日(月)暈,日(月)耳, 日冠(抱), 月呑(食)行星, 月隱食, 兩日竝出, etc.
- Planets : 太白(歲星)晝見, 太白經天, 行星入(食)月, 行星犯行星, 熒惑退舍-, 行星聚-, 流星(飛星-天狗-枉矢星), 彗星, 孛星, etc.
- Stars : 客星, 妖星, 老人星, 星見于晝, 有星于-, etc.
- Aurora : 赤(黃-青-白)氣如火, 赤祲, 赤氣經天, 赤虹衝天, etc.

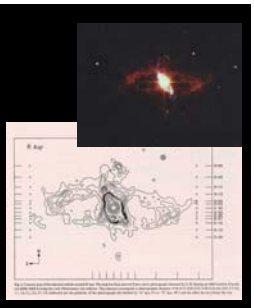
Records in Goryeosa : The Sun

I. Korean Nova Records in A.D.1073 and 1074: R Aquarii

A&A 435, 207-214 (2005)

H.-J. Yang, M.-G. Park, S.-H. Cho, and C. Park

R Aquarii ?



symbiotic system
jet
accretion disk
two nebulosities
historical records !

1816	1940,3	1944	1982	1985
Harding	Hubble	Baade	(Nature)	Li
(P:386.83d)	(expansion)	(~600yr)	(Jap. record)	(Kor. record?)

Previous Works

- **Kafatos & Michalitsianos** (Nature 1982)
  - suggested that the Japanese record of A.D. 930 is associated with an outburst record of R Aqr
    [The Japanese record: 客星入羽林 始西行於羽林]
  - suggested highly eccentric, supercritical accretion
- **Li Jiang** (Ch. A&A 1985)
  - suggested that the Japanese record should be considered as referring to a comet, not a nova
  - suggested two Korean records of R Aqr: 1073 & 1133 (but, the record of 1133 is considered as a comet)

- **Historical Nova Records**
  - Lundmark (1921): Chinese records from Biot (1846) & Williams (1871)
  - Hsi (1958): Chinese records of 90 suspected novae
- **Korean New Star Records**
  - "Guest Star (客星)" and "Peculiar Star (妖星)"
  - searched and compiled all records from
    Samguksagi (三國史記),
    Goryeosa (高麗史), and
    Joseonwangjosillok (朝鮮王朝實錄)

Korean Historical Guest Star Records

- the first guest star record appears in A.D. 85, and the second in A.D. 867 (Samguksagi)
- cannot find any Crab SN record in 1054
  : the political disorder in the early Goryeo Dynasty
- two Guest Star records-outburst of R Aquarii
  : records of A.D. 1073 and 1074
- two SN records of Tycho's (1572) & Kepler's (1604)
  : recorded faithfully in Joseonwangjosillok

Korean Historical Guest Star Records
(Yang et al. 2005 A&A)

Date of observation[a,b]	JD[c]	Associated[d] constellations	Ref.[e]	Duration[f] (days)	Note[g]
– May/June 85	1 752 255	Dra/UMi/Cep	S, M		
– Jan. 154	1 777 321	–	S, M		
– Oct./Nov. 299	1 830 571	–	S, M		
– – 662	–	–	M		
– Dec./Jan. 867/868	2 038 094	Lib/Sco/Sgr	S, M		
01 Aug. 1065	2 110 262	–	G, M		
10 Sep. 1073	2 113 224	Aqr/Psc/Cap	G, M		
19 Aug. 1074	2 113 567	Aqr/Psc/Cap	G, M		
10 Aug. 1163	2 146 065	Oph	G, M		
03 May 1356	2 216 460	Tau	G, M		
09 June 1363	2 219 053	–	G, M		Shower
22 May 1391	2 229 262	Dra/UMi/Cep	G, M		
05 Jan. 1399	2 232 047	Oph	J, M		
11 Mar. 1437	2 245 992	Sco	J, M	14	
24 Aug. 1499	2 268 803	Dra/UMi	J, M	4	Comet
06 Nov. 1572	2 295 541	Cas	J, M		
23 Nov. 1592	2 302 853	Cet	J, M	457	
30 Nov. 1592	2 302 860	Cas	J, M	118	
04 Dec. 1592	2 302 863	Cas	J, M	115	
12 Dec. 1592	2 302 872	And?	J		
18 Jan. 1593	2 302 909	And?	J		?
– Nov./Dec. 1600	2 305 782	Sco	M		Type^{b}?
– Dec./Jan. 1600/1601	2 305 813	Sco	M		Type?
13 Oct. 1604	2 307 195	Sco	J, M	201	
27 Oct. 1639	2 319 992	Lep	J	3	Comet
04 Feb. 1661	2 327 763	Del/Aql	J	5	Comet
13 Dec. 1661	2 328 075	Aqr	J, M	20	Comet
20 Nov. 1684	2 336 453	Vir	M		
22 Apr. 1702	2 342 814	Sco/Sgr	J, M	9	Comet
13 Feb. 1737	2 355 530	Peg/Aqr/Cep	J		
06 Mar. 1742	2 357 377	Sgr/Cap	J	2	Comet
13 Feb. 1743	2 357 721	Crv-UMa-Crt	J, M	9	Comet
06 Jan. 1744	2 358 048	Peg/And/Aqr	J	2	Comet?
17 Nov. 1744	2 358 364	Vir	J	2	Comet
02 May. 1748	2 359 626	Peg	J		
19 Dec. 1759	2 363 874	Cet	J		
08 Jan. 1760	2 363 894	Cma-Cet	J, M	14	Comet
09 Feb. 1760	2 363 926	Leo	J, M	11	Comet
29 June 1770	2 367 719	Oph-Cap-Sgr	J, M	4	Comet

The Guest Star records in A.D. 1073 & 1074

(from Goryeosa)

Date of Observation (JD)	The Original	Text description (Associated Constellations)
1073. 9. 10. (2113224)	文宗二十七年八月丁丑 客星見于東壁星南	A guest star appeared at the south of Dong-Byeok (Aqr/Psc/Cap)
1074. 8. 19. (2113567)	文宗二十八年七月庚申 客星見東壁星南大如木瓜	A guest star, as big as a MokGwa, appeared at the south of DongByeok (Aqr/Psc/Cap)

The two records are same one ?

I. the two lunar dates with 60 cyclical days
: 丁丑 ≠ 庚申, **absolute different** !!!

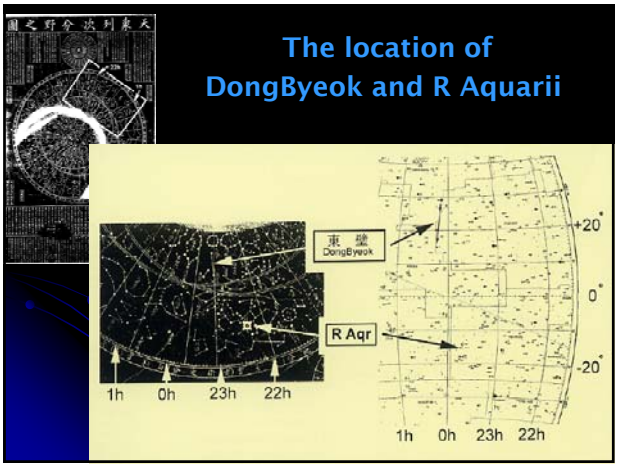
II. the record of 1074 includes the size information
: as big as **a MokGwa** (木瓜: a Korean quince)

III. an observation of Venus at daylight was recorded at the same day of 1073
: mag. of Venus at 10 Sep, 1073 was -4.^{m}19,
whereas, the mean mag. of Venus is -3.^{m}19

Guest Stars in 1073 & 1074 : R Aqr

- **DongByeok** (東壁: α AND and γ PEG)
- **R Aqr** : RA 23^h 43^m.8, Dec. -15° 17′ (J2000.0)
- **R Aqr is located in Urim (羽林),**
which is one of the minor oriental constellations, but, recorded in the south of DongByeok (東壁)
- **Urim** consists of 45 stars and occupies the region of ~ RA 20^h 30^m ~ 23^h 20^m, Dec. -20° ~ 0°

The location of DongByeok and R Aquarii



Identifications

1) checked novae, SNe and cataclysmic variable stars within 40° × 40° in the south of DongByeok
⇒ **have not found any candidate nova and SN**

2) why the location is described as the south of DongByeok instead of within Urim
⇒ **positions based on 28 oriental constellations**

3) consider the brightness of the reference stars
DongByeok (m=2.^{m}24) > Urim (m=3.^{m}54)
⇒ **a brighter star would be used as a ref. star**

Implications for R Aqr (I) : Distance

* Baade (1944) -- 260 pc : 600 yr ago
* Lépine et al (1978) -- 181 pc : Mira abs. mag.
* Solf & Ulrich (1985) -- 180 pc : 600 yr ago
* Whitelock (1987) -- 250 pc
* Yang et al. (2005) -- ~273 pc : Korean records

- from the epoch of outburst to be A.D. 1074,
55km/s with an angular radius of 48"
and, constant rate of expansion (Baade),

We estimate the kinematical distance = 273 pc

Implications for R Aqr (II) : Brightness

- estimate the brightness from the record of 1074
- 94 records as a MokGwa in Goryeosa
  (91 meteors, 2 comets, and 1 nova)

- in meteor records,
  no <  <  <  <  < 

No (472) ~ 5 mag. | Egg (25) ~ 4 mag. | Cup (43) ~3 mag. | Quince (91) ~ 2 mag. | bowl (2) ~1 mag. | Basin (25) ~ 0 mag.

we estimate,
MokGwa : 1~2 mag. and from the distance,

$M_{outburst}$ = -6.2 ~ -5.2 mag.

Implications for R Aqr (III) : Models

- models for outburst of R Aqr

" Two successive outbursts in one year "
" The outburst of 1074 brighter than that of 1073"
" No outburst since then has been recorded"

< previously suggested models for R Aqr >

I. Kafatos & Michalitsianos (1982):
highly eccentric supercritical model ➡ Impossible !

II. Henney & Dyson (1992) : Sedov- type shell motion
$R_s(t)=R_0(t/t_0)^{3/5}$ ≈ 450 pc, ➡ too large !

Summary & Discussion

I. searched and compiled all Korean historical records of "Guest Star" and "Peculiar Star"

I. found two guest star records in 1073 & 1074 that can be related with outburst of R Aqr

I. identify the two records with outburst of R Aqr

I. implications for R Aqr
- kinematical distance ~273 pc
- apparent mag. is 1~2 mag. → $M_{outburst}$ = -6.2 ~ -5.2 mag.
- propose models for outburst of R Aqr
  : provide significant restrictions to models

II. Analysis of Historical Meteor and Meteor Shower Records : Korea, China, and Japan

Icarus 175, 215-225 (2005)

H.-J. Yang, C. Park, and M.-G. Park

Comet and Meteor Shower

- The relationship between meteor shower and comet was known in the 18C
- Comet - meteor stream/(shower, meteorite) - dissipation/(sporadic meteor)
- Meteor shower ? ZHR ≥ few hundreds ~ few thousands
- The timescale of meteor stream is known 2~4 years for Leonid shower (Yeomans 1981, Williams 1997, Wu 2000)
- Basic period of periodic meteor shower is sidereal year (365.2564 days)

Previous Works

- Imoto & Hasegawa (1958) : Historical Records of Meteor shower in China, Korea, and Japan
- Hasegawa (1980, 1992) : Historical Meteor showers in Japan and China
- Hasegawa (1998) : Historical Meteor shower records during Goryeo Dynasty
- Rada & Stephenson (1992) : 10C Arabic Meteor showers
- Mason (1995) : Historical worldwide Leonids
- Ahn et al. (2002), Ahn (2003) : Korean Meteor showers during Goryer Dynasty

Tables of Korean historical shower records

Date of Observation *2 (Y M D)	Date Info.3	J D	Day 4	Corresponding Meteor shower	Estimated date of shower *5	Note 6
104 2/3 –	M	1759102	82			1
454 – –	Y	–	–			1
532 8 28	D	1915611	261			1
581 3 20	D	1933347	100			1
586 5/6 –	M	1935252	178			1
643 11 1	D	1956218	325			1
647 9/10 –	M	1957636	282			1
684 11/12 –	M	1971220	351			1
706 4/5 –	M	1979045	141			1
718 10/11 –	M	1983622	334			1
765 1 7	D	2000481	26			1
801 10/11–	M	2013921	317	Leonids7 ?	801 10 11 B	1
905 3/4 –	M	2051691	101			1
1095 7 25	D	2121212	223	Perseids	1051 7 24 C	3
1042 7 25	D	2101854	223	Perseids	917 7 25 C	1

Date of Observation *2 (Y M D)	Date Info.3	J D	Day 4	Corresponding Meteor shower	Estimated date of shower *5	Note 6
1103 9 7	D	2124178	267			3
1106 7 27	D	2125232	225	Perseids	1051 7 24 C	3
1111 10 2	D	2127125	292	Leonids	1111 10 11 B	3
1136 4 3	D	2136075	110			1
1178 9 17	D	2151582	277			2
1179 4 17	D	2151794	123	η Aquarids	1150 4 20 C	3
1532 10 24	D	2280918	312	Leonids	1532 10 24.9 A	1
1533 10 24	D	2281283	312	Leonids	1533 10 25.0 A	1
1548 8 24	D	2286701	251			1
1560 8 24	D	2291084	251			1
1566 10 26	D	2293338	313	Leonids	1566 10 25.9 A	1
1625 11 6	D	2314889	314	Leonids	1625 11 5.9 A	1
1602 11 12	D	2306494	320	Leonids	1602 11 6.9 A	1

The Number of Historical Records

Country	Epoch	Duration (yr)	Number of		
			meteor	meteor shower	meteorite
Korea	The Three Kingdoms period (-54 ~ 935)	991	26	11	11
	Goryeo dynasty (918 ~ 1392)	475	731	4	38
	Joseon dynasty (1392 ~ 1910)	519	3104	6	5
China	-645 ~ 918	1565	368	35	60
	919 ~ 1391	473	1786	16	25
	1392 ~ 1911	520	3521	225	299
Japan	636 ~ 917	282	73	5	15
	918 ~ 1391	474	78	5	2
	1392 ~ 1583	192	280	3	14

16.5 %

14.7 %

16.7 %

Analysis of Korean Records

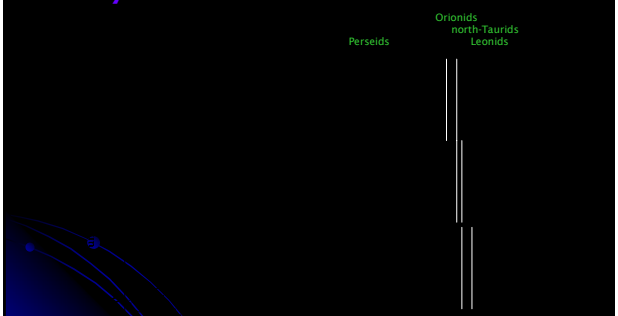
I. Data analysis
- dates conversion into JD
- data rearrangement with sidereal period

II. Monte-Carlo analysis
- random generating for each 10,000 data set with given following background distributions
  - -> The three Kingdoms period: all records (179)
  - -> Goryeo dynasty: planetary and lunar records (3,534)
  - -> Joseon dynasty: planetary records (18,697)

III. Identified shower records
: Perseids, Orionids, north-Taurids, and Leonids

Korean meteor & shower distributions

Analysis of Korean Meteor Records



Seasonal variations of Korean Astronomical Records

Chinese Meteor Shower Records

Japanese Meteor & Shower Records

Seasonal Variations

- According to Yrjölä & Jenniskens (1998),

$N(H,\lambda_\odot) = \langle N_{spo} \rangle (H) -/+ \Delta N_{spo}(H) \cos(\lambda_\odot)$

where, $\langle N_{spo} \rangle$ = the mean daily sporadic hourly count

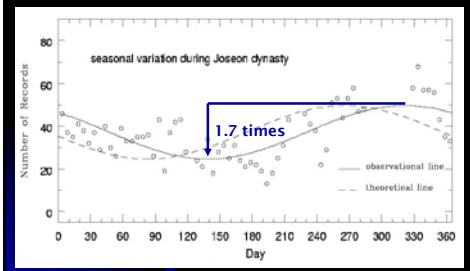
ΔN_{spo} = yearly amplitude

- Data for Joseon dynasty (423 years)

$N(\lambda_\odot) = \langle N_{spo} \rangle + \Delta N_{spo} \sin(\lambda_\odot + \Phi)$

where, Φ = the possible phase shift

Seasonal Variation of Sporadic Meteors



$\langle N_{spo} \rangle$= 37.207

ΔN_{spo}= 12.525

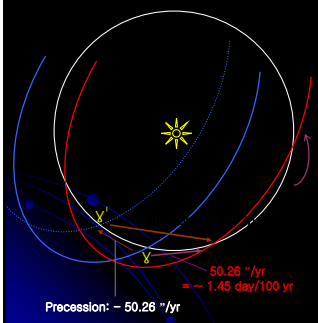
Φ = 55 days

$\Delta N_{spo} / \langle N_{spo} \rangle \approx 1/3$

Summary & Discussion

- ✓ compiled and analyzed Korean historical meteor records
- ✓ also, analyzed Chinese shower & Japanese meteor records
- ✓ confirmed some shower records
  : Perseids, Orionids, north-Taurids, and Leonids
- ✓ confirmed some showers persist from Goryeo to Joseon dynasties, almost one thousand years
- ✓ activities of Orionids, north-Taurids, and Leonids have increased
- ✓ activity of Perseids has decreased over the last 1000 years
- ✓ analyzed seasonal variation of sporadic meteors

Leonid meteor shower



- Tropical yr = 365.2422 day
- Sidereal yr = 365.2564 day
- Sid. –Trop. = 1.42 day/100 yr

Day = counting day within sid. period
(Jan. 1, 2000 = day 1)

In sidereal period,
- Time delay of Leonids by perturbation 1.45 day/100yr
- corresponding date of Leonids
  - A.D. 2000 : day 321
  - Joseon dynasty: days 312~320
  - Goryeo dynasty: days 305~312
  - The Three Kingdoms: days 299~305