An Evaluation of Astronomical Observations in the Irish Annals

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Summary

The astronomical entries scattered through the Irish annals have been examined in a serious astronomical context by R.R. Newton as part of his research into the accelerations of the earth and moon, and by D. Schove and A. Fletcher as part of the Spectrum of Time project. They have never however been fully collated and examined as a whole as this paper undertakes to do. What emerges is a body of records from 442 to 1133 documenting eclipses, comets, aurorae, volcanic dust clouds and possibly a supernova; from 664 to 1133 all of these records are of observations made in or near Ireland, and most of them are accurate in their chronological and descriptive details. Analysis of the details of these records implies that at least from the seventh to the eleventh centuries careful and sustained observation and recording of astronomical phenomena was conducted in some Irish monasteries and it is clear that the underlying motive was religious and specifically eschatological, ie to detect the first signs of the end of time as prognosticated in the book of Revelations. Critical examination of this data allows us to throw new light on the circumstances of the Synod of Whitby in 664, to identify the date of the eruption of the volcano Eldgjá in Iceland as the springtime of 939 and to identify a possible Western observation of the supernova of 1054.

1. Introduction[2]

The Irish annals are a unique and very substantial historical resource, providing an annual summary of events as viewed from a monastic perspective from around the time of the arrival of Christianity in the island in the early fifth century, until the dissolution of the monasteries at the end of the sixteenth century. It has been shown conclusively by Smyth (1972, p.4-11) that from the middle of the sixth century, and except of course when they copy items from foreign chronicles, these summaries are contemporary reports of Irish events. They exist today as about a dozen major collections, the best guide to which is that given by Mac Niocaill (1975, p.11-49), and a helpful introduction to which is given by K. Hughes(1972, p.97-159). Whilst by far the bulk of this vast collection of records provides a cryptic, anonymous and detached summary of events in the ecclesiastical and political life of the country, scattered through them are occasional references to astronomical and terrestrial phenomena such as eclipses, comets, strange clouds, earthquakes, storms, famines, plagues, etcetera; the astronomical entries have never been fully assessed either with regard to their possible meaning or with regard to their chronological accuracy, and it is these that form the subject of this paper.

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[2] A version of this paper emphasizing the textual and historical issues will appear as 'Astronomical Observations in the Irish Annals and their Motiviation' in the forthcoming edition of *Peritia*, Cork.

Identification of these records commenced with the eclipse entries and the modern printed editions of the annals frequently give footnotes with dates, times and magnitudes for many such records, see Mac Carthy (1901, p.140), Mac Airt (1951) and Mac Airt & Mac Niocaill (1983). The first serious appraisal was made by R.R. Newton (1972, p.181-99 & 1979, p.240) as part of his research into the rotational speeds of the earth and moon, however it was not until the late 1970's when D.J. Schove and A. Fletcher collaborated, that any systematic attempt was made to evaluate most of the Irish eclipse data; in a mammoth undertaking Fletcher assessed all of the eclipse records that he found in Western chronicles for the years 1-1000 AD and, presenting lucid discussions of the chronicle entries and astronomical considerations and bringing together earlier analyses including those of Newton, justified most and corrected a few of Mac Carthy's earlier identifications. In the case of the comets however, as a consequence of Prof. Fletcher's death, no systematic evaluation of the Western sources was undertaken, with the result that no Irish comet records are included in the comet list prepared by Schove (1984, p.xxxiii & 285-97).

This work by Schove and Fletcher demonstrated conclusively that the Irish annals contained both accurate and unique accounts of Irish observations of eclipses visible from Western Europe between 594 and 921, and at a time at which few locations in that large area were recording any astronomical observations. But of course their work on such a global scale could in no way provide an assessment of either the extent or the quality of any of the individual sources on which it drew. Firstly it was effectively restricted to the eclipses occuring between 1 and 1000 AD. Secondly when discussing dates for Irish eclipse records from the Annals of Ulster, which provides the majority of such, their discussion was frequently coloured by B. Mac Carthy's judgement that between 486 and 1012 the manuscript dates are all one year too low, which judgement has recently been shown to be incorrect as will be discussed below. Thirdly Fletcher's lucid evaluations of the Irish eclipse records are naturally scattered diffusely through his further discussion of the entire Western collection of eclipse records, making it difficult to form a judgement on the performance of the Irish records. For all these reasons and in order to place a clear account of the Irish records before those interested in the history of astronomical observations in the British Isles, it was considered worthwhile to undertake an assessment of the totality of all astronomical entries in the Irish annals[3].

The list of twelve annals examined and their acronyms is given in the reference section under 'Annals' and, while this list does not exhaust the supply of Irish annals, those ommitted are either minor or later collections[4]. This examination resulted in 92

[3] The recent publication by B. Hetherington (1996) *A Chronicle of Pre-Telescopic Astronomy* , nothwithstanding its all-encompassing agenda, is not an adequate treatment of the material; the citations, all paraphrases, are frequently incomplete and 21 events recorded in these annals are omitted and one, the eclipse of 612, is misdated to 614.

[4] Mac Niocaill (1975,p.40-7) tabulates the full collection of Irish annals.

excerpts referring to thirty seven different events; the Annals of Ulster (AU) with 31 entries followed by the Annals of Tigernach (AT) and *Chronicon Scotorum* (CS) with 19 and 18 entries respectively are by far the most important sources.

When collating entries from different annals it is obviously necessary to use a uniform chronological apparatus to order the records and the first problem here is that most Irish annals do not use the familiar *Anno Domini*, particularly up to *circa* 1000. Even when they do it may not be an AD which changes on the first day of January and Mc Carthy (1994a, p.54-60) has shown that all the AD data of AU up to 1012 increments on the feast of the Assumption (25 March), so to convert to our system which changes on 1 January it is necessary to increment the MS AD year, and this has been done in all references to AU in Table 1. In the case of AT, no AD data occurs in either the MS or the modern edition before 1020, so references are left blank before 1020 and after that the MS AD data are used. In the case of CS, the modern editor Hennessy (1866, p. xlvi-ii) provided a chronological table based on MS criteria, so this has been used in all references cited below in Table 1. For the remaining annals we simply cite the AD year given in their modern editions.

2. Evaluation of the Astronomical Entries

The astronomical entries abstracted from the annals were separated into groups based on both their textual content and their existing chronological position in the edition from which they were taken. Three different languages are represented in the sources, so an English translation representing the 'sum' of all the entries of the group was made such that the translation reflects the total of all the information in the group. For example, at 1023 the clearly-related entries in AU and ALC record the dates of the lunar and solar eclipses, whereas a quite distinct entry in CS, AT and AC records that the solar eclipse occurred about noon, so the translation incorporates both the date and time details. This translation is followed in all cases by the acronym(s) of its annal source(s), each concatenated with the AD year appropriate to the entry as discussed above. Examination of these translations shows that most of the entries clearly represent either a lunar or solar eclipse, some a comet or an aurora and just a few entries where the phenomenon was ambiguous or uncertain, and so to these translations were added evaluations as follows: Eclipses - Entries which were either certainly or possibly eclipses were modelled on the desktop planetarium *Voyager* as viewed from the location of the monastery of Durrow in Co. Offaly (7˚31' W, 53˚20' N). This site was chosen because it is centrally located in Ireland and so gives a good impression of the view from other parts of the island, and Durrow is known to have been an annalistic centre since its foundation by S. Columcille in 551, and as we shall see, there are good reasons to associate this monastery with astronomical observation. The *Voyager* program was used because it is a program readily available for PC and Macintosh computers, so permitting others to check or explore the

results here cited, it has a good reputation for accuracy, and its specified planetary accuracy of between 5 to 10 arcminutes for events before 1500 is more than adequate for most of the situations described in the Irish annals[5]. From these simulations were recorded times of maximum eclipse at Durrow in Universal time (UT), and the following data relevant to the appearance of the eclipse.

Rs = Radius of the sun's disc in arcminutes.

Rm = Radius of the moon's disc in arcminutes.

Ru = Radius of the earth's umbral shadow in arcminutes.

Sep = Separation between the centres of the appropriate discs in arcminutes.

These data are sufficient to deduce, not only the appearance of the event from Durrow but, from the relative values of Rs and Rm and Sep, whether a solar eclipse may have been total nearby, or, from the relative values of Rm and Ru and Sep, how deep was the moon's immersion in the earth's umbra. These simulations were then collated with the analyses given by Fletcher in D.J. Schove's *Chronology of Eclipses and Comets AD 1-1000*, with which, in general, excellent agreement was found.

Comets - These were collated with the list of Chinese cometary observations published by Ho Peng Yoke (1962, pp. 127-225) and checked against the update of Hasegawa (1980, pp. 59-102), and an identification was made by citing the appropriate section of the Chinese description of the event given by Peng Yoke.

Aurorae - These were assessed against the chronological synthesis in appendix F of Schove (1984) and against his table of sunspot cycles from 649 BC to 2004 AD in Schove (1955), and from these an identification was made by citing this data.

Volcanic clouds - Whilst these are strictly terrestrial events, because the two references to events at 627 and 939 both refer to the sun and can be confused with a solar eclipse, it was decided to include them for the sake of clarity. Both were identified with the help of Mike Baillie from the Dendrochronology unit at Queen's University of Belfast, who provided the appropriate references.

From these sources it was possible to establish satisfactory identifications for all the groups of annals' entries except that for 1054, discussion of which is deferred until section 5. These were assembled in chronological order and are presented as Table 1 below.

Table 1. A translation and evaluation of all references to astronomical phenomena in the Irish Annals; the citations will all be found in Appendix 1. Note that all times are UT unless otherwise indicated and that all eclipse calculations have been done from 7˚ 31' W, 53˚20' N, ie. site of the monastery of Durrow, approximately in the middle of Ireland. All references to 'Fletcher' in this table will be found in D.J. Schove (1984) under the year of the eclipse cited.

442 A star which is called a comet shone for a long time - Marcellinus 442 + AI 442.
Ho Peng-Yoke (1962, p.163) cites as follows: '10th November 442 "... a comet appeared at *Thien-*

[5] Schaefer, (1993, p. 313) cites its reputation, and Voyager (1990, p.128) specifies the planetary accuracy.

Lao [Ursa Major] ... More than a hundred days later it disappeared in the W."', making identification quite certain, but AI has clearly borrowed it from the chronicle of Marcellinus of Constantinople, see Mommsen (1894, p.37-108).

447 An eclipse of the sun at the ninth hour - AI 444.
Voyager: Solar eclipse at 12:58 on 23 Dec. 447, Rs=16.3', Rm=16.8',Sep.=1'.
Track=E. Atlantic, Portugal, France, Germany. This entry has been borrowed, with great reduction, from the *Chronicon Luxoviense,* which in turn has borrowed it from the extension to the chronicle of Jerome published by the Spanish bishop Hydatius *circa* 468, see Burgess (1993, pp. 22 & 166). Fletcher, while not realising it was borrowed from the *Chronicon Luxoviense,* corrected earlier identifications of 20 July 445 for this entry and pointed out that the phrase 'from the eighth hour to the ninth' is appropriate to central France and surmised correctly that the entry was borrowed from there. In a monastic context, reference to a solar eclipse at the ninth hour inevitably recalls the Evangelist Luke's account of the Crucifixion 'there was darkness over the whole land until the ninth hour and the sun was darkened', Luke 23.44-5.

497 An eclipse of the sun was visible - AU 496 + CS 493 + AT + Marcellinus 497.
Voyager: A solar eclipse at 13:50 on 18 Apr. 497. Rs=15.8', Rm=15.5', Sep.=25'. Track= W. Africa, N. Africa, E. Mediterranean. Just visible from Ireland but clearly borrowed from Marcellinus.

512 There was an eclipse of the sun - AU 512 + CS 510 + Marcellinus 512.
Voyager: Solar eclipse at 07:40 on 29 June 512. Rs=15.7', Rm=16.3', Sep.=22'.
Track=NW. Africa, central Mediterranean, Balkans, Asia Minor. Just visible from Ireland but again clearly borrowed from Marcellinus.

594 An eclipse of the sun, ie. a dark morning - AU 591/2 + CS 590 + AT + AI 594.
Voyager: Solar eclipse at 05:58 on 23 July 594, Rs=15.8', Rm=15.8', Sep.=3'.
Track=S. Ireland, central England, France. Fletcher was the first to draw attention to the fact that the word *matutina* connotes the dawn, effectively ruling out the eclipse at 8:37 on 19 Mar. 592 which was originally proposed by Mac Carthy but occurred long after dawn. Textually all the five annals' records are clearly related and hence Fletcher resolved that 'the great Irish total eclipse of the decade, namely S.594 July 23, is not merely present in the Irish annals, but also occurs in some cases with the correct year indicator', ie. CS and AT both have feria .vi., which is appopriate for 594. He further concluded that 'certainly this is the first genuine eclipse record from the British Isles'.

612 A star was seen at the eighth hour of the day - AU 614 + CS 614 + AT + AF 614 + AC 617.
Voyager: A solar eclipse at 15:13 on 2 Aug. 612. Rs=15.8',Rm=16.9',Sep.=9'. Track=E. Atlantic, SW Portugal, NW Africa. At 15:38 UT in SW. Portugal (8˚07' W, 38˚ 23' N) this was seen as a deep eclipse that occurred just about 2˚ east of the first magnitude star alpha Leonis, ie. Regulus mag. 1.35, which certainly would thus become visible when viewed from totality during the ninth sundial hour, local time in Portugal. At the time of the eclipse the planets Mercury, Mars and Venus lay between 8˚ and 14˚ west of the sun, but the singular 'star' ensures that the reference cannot be to these. Thus the annals' data would fit nearly perfectly a record from this part of Portugal which was just about 100 miles west of Seville in Spain where Isidore flourished at this time. Fontaine (1960, p.4-5), in his edition of Isidore's *De natura rerum,* argues convincingly that it was this eclipse which caused king Sesibut to request Isidore to write this work. Since *De natura rerum* was widely referenced by the seventh century Irish computists, it seems quite likely that along with their copy of this work they also received from Spain an account of the circumstances of its composition, ie. the eclipse. The entry, which differs from all other eclipse records in the annals, appears to be just part of such an account. In any case it is certain that the entry is borrowed. Fletcher asserts that Isidore 'does not seem to record it' and he was himself dubious about this identification, but was apparently unaware of the role it played in the composition of *De natura rerum*. Note that the number *.viiii.* readily corrupts to *.viii.* or *.vii.* and that AU characteristically transmits a more accurate record.

627 A solar eclipse - AI 626. A dark year - AU 625 + AT.
There was no appropriate solar eclipse in or near this year, so it appears that AI is a corrupt version of AU and AT's visibility report, which Fletcher associated with the volcanic erruption which occurred *circa* 626. There is a specific record of an observation of this in the chronicle of Michael the

Syrian as follows: ‘In the year AD 626 the light of half of the sphere of the sun disappeared, and there was darkness from October to June. As a result people said the sun would never be restored to its original state’, cited from Stothers et al. (1983, p. 6363). If the year cited here is correct then AU 625 must refer to the year 627, since a volcanic dust cloud event commencing in October 626 could not reasonably be described as a ‘year’ - *annus* - in the following December, and thus we cite 627 as the year appropriate to the annals; however Fletcher’s discussion indicates that there is some uncertainty about 626. Dr. Breen has examined the sources cited by Stothers, the chronicle of Michael the Syrian, the chronicle of Agapius of Hieraolis and the panegyric by George of Pisidia on the Emperor Heracleidos, and concluded on textual grounds that the annals’ entry is independent of them all. We take it therefore to be a record of an independent observation.

664 Darkness on the kalends of May [1 May] at the ninth hour and in the same summer the sky seemed to be on fire - AU 664 + CS 664 + AT + AFM 664.

Voyager: A solar eclipse at 16:50 on 1 May 664. Rs=15.7’, Rm=16.5’, Sep.=3’. Track=N. Atlantic, off N. coast of Ireland, SW. Scotland, NE. England, N. Sea. Seen as total from SW Scotland and NE England. Sundial time ninth hour = 14:54 to 16:11 UT, so the eclipse commenced in the ninth hour. This is certainly a completely accurate insular observation and Fletcher’s remark that ‘Ireland is correct on the day and weak on the year’ is inappropriate, since AU correctly records the year. Since Schove (1955, p. 134) cites 665 as a year of auroral maximum, the record that ‘in the same summer the sky seemed to be on fire’ appears to be a good report of aurorae in the latter half of 664. The annals also report plague in Ireland this year, so that 664 was a ‘portentous’ year; see the next entry and section 4 for its relationship with the Synod of Whitby.

672 A thin and tremulous cloud in the shape of a rainbow appeared at the fourth vigil of night on the sixth feria [Friday] preceding Easter, from east to west through a clear sky. The moon became [the colour of] blood - AU 674 + CS 674 + AT + AC670.

Voyager: Lunar eclipse at 19:38 on 10 Nov. 672, Ru=45’,Rm=16.7’, Sep.=7’. The description of the cloud is quite remarkable for the number of its descriptive and contextual details, suggesting thereby that it was unprecedented in the observer’s experience. Notwithstanding these details it is not easy to derive a satisfactory identification; the description itself, the time of the night and the fact that Schove (1955, p.134) reports that 671 was a year of auroral minimum, all preclude the possibility that it was an auroral phenomenon. The description of it as passing from east to west in the shape of an arc perhaps suggests a long linear cloud feature with billows(*tremulus*) passing within 45° of the zenith and having a bowed appearance as a consequence of perspective. Noctilucent clouds display these characteristics occasionally, but they are a phenomenon of summer, so the Easter date precludes them. Recently long linear clouds in clear air have been reported, but their origin is uncertain, see Saunders (1990); the passage of a meteorite through clear air holding supercooled water vapour is one possibility. Fletcher was skeptical about the lunar eclipse, but we note a predilection in these annals for double or multiple signs or portents, cf. 447, 664, 691, 735, 763 and lunar/solar eclipse pairs at 753, 865, 878 and 1023, so we see no reason to doubt the eclipse. From such a deep position in the umbra on 10 Nov. 672, the moon could very well appear red.

676 A bright comet was seen in the months of September and October - AU 677 + CS 677 + AT + AC 673.

Peng-Yoke (1962, p. 169) cites from five Chinese sources: ‘4th September 676 “... a comet appeared at the *Tung-Ching* [Gemini]. After 58 days it went out of sight”’, so there is no doubt concerning this identification first made by Kiang in Mac Niocaill (1975, p.144). Bede’s report of this comet in *Historia Ecclesiastica* IV.12, where he places it in August 678 and lasting for three months, is taken from *Liber Pontificalis*; the Irish report is clearly independent of both Bede and *Liber Pontificalis*, see Davis (1989, p.73).

688 Part of the sun obscured - AU 689 + CS 689 + AT.

Voyager: A solar eclipse at 08:00 on 3 July 688. Rs=15.8’, Rm=15.6’, Sep.=11’. Track= Eastern US., Iceland, N. Scandinavia. Although it is an eclipse of low magnitude, its track implies it was certainly an insular observation. This is also Fletcher’s conclusion, but his assertion that ‘the +1 correction to AU over several centuries is merely what statisticians call the “mode”’, is incorrect.

691 The moon [turned] to the colour of blood on the Feast of the Nativity of S. Martin[11 Nov.] - AU 692 + CS 692 + AT + AC 687.
Voyager: Lunar eclipse at 17:10 on 11 Nov. 691. Ru=42', Rs=15.8', Sep.=35'. Although immersion in the umbra is slight, the dates match exactly so there can be no doubt concerning the identification; it is an example of a double portent.

719 An eclipse of the moon at its full - AU 718.
Voyager: Lunar eclipse at 01:43 on 2 Nov. 719. Ru=39', Rm=15.0', Sep.=10'. We prefer this identification, notwithstanding the error in the year, to the lunar eclipse on 12 Nov 718 which Fletcher identified for this entry because, on that occasion, the moon barely entered the umbra.

726 A dark and blood-red moon on the eighteenth of the kalends of January [15 Dec 725] - AU 725.
Voyager: A lunar eclipse at 22:08 on 13 Dec. 726. Ru=44.5', Rs=15.8', Sep.=8'. This is also Fletcher's identification against the 24 December 725 given by Mac Carthy. The corruption in the MS date is probably an attempt to adjust the entry to a new lunar cycle.

734 A lunar eclipse on the eleventh of the kalends of February[22 Jan] - AU 734 +AT.
Voyager: Lunar eclipse at 2:30 on 24 Jan. 734. Ru=43', Rm=16.2', Sep.=9'. The 24 January = ninth kalends February but, since the number *.viiii.* does not readily corrupt to *.xi.*, as at 726, their proximity suggests an adjustment to accomodate the entry to a new lunar cycle.

735 A huge dragon was seen, with great thunder after it, at the end of the autumn - AU 735+AT.
Schove (1955, p.134) gives 735 as a year of sunspot maximum so we suggest this is an observation of the aurora Borealis combined with a thunder storm, and another example of a double portent.

744 A horrible and wonderful sign was seen in the stars at night - AU 745 & 765 + AT twice.
This item is duplicated in both AU and AT twenty years apart, but it isn't clear what it is; while an aurora seems possible, other contemporary reports describe aurorae as 'dragons', so that a comet seems more likely. Curiously, Peng-Yoke (1982, p.171) also reports comets 20 years apart as follows: 'Winter, 744. *The Chronicle of Silla* says, "In winter, in the third year of the Kyongdok Wang an "ominous star" as large as a five-peck measure appeared in the central heavens. It went out of sight after ten days"' and 'April-May, 764. *The Chronicle of Silla* says "In the third month of the 23rd year of Kyongdok Wang [6th April to 5th May] a (*po*) comet appeared in the SE"'. However, since the annals' entries seem to be clearly duplicates of each other we can only accept one of these, and on the basis of both its position and description, the first seems the more probable.

745 Dragons were seen in the sky - AU 746 + AT.
Schove (1955, p.134) gives 745 as a year of very strong sunspot maximum, so we suggest this is a report of repeated auroral observations.

753 A dark sun - AU 753 + AT
Voyager: A solar eclipse at 10:10 on 9 Jan. 753. Rs=16.2', Rm=14.8', Sep.=3'. Track=British Isles, France, N. Mediterranean.
The colour of blood upon the moon in this year - AT + AC 749.
Voyager: A lunar eclipse at 0:50 on 24 Jan. 753. Ru=47', Rm=16.9', Sep.=36'. This is the first instance of a solar/lunar eclipse pair in these annals and Fletcher derives these same identifications.

763 A great snowfall and a dark moon - AU 762 + AT.
Voyager: Lunar eclipse at 3:38 on 25 Dec. 763. Ru=42', Rm=15.8', Sep.=36'. The moon was more than half immersed in the umbra, but the combination of great snow and an eclipse appears to be the point of the annal, cf. 672 . Fletcher noted other winter lunar eclipses at 15 Jan. 762 and 4 Jan. 763, but argued convincingly for 25 Dec. 763 on the basis that 'the cold and snow of the 763/764 winter was outstanding in Europe generally'.

764 A dark sun at the third hour of the day - AU 763 + AT.
Voyager: Solar eclipse at 9:55 on 4 June 764. Rs=15.7', Rm=15.2', Sep.=3'. Track=S. Atlantic, S. British Isles, Poland. Sunrise at 4:01 and sunset at 20:51 implies that the eclipse developed during the fourth hour to a maximum at the start of the fifth hour; Fletcher and Mac Carthy both made this identification.

773 A dark moon on the second of the nones of December[4 Dec] - AU 773.
Voyager: A lunar eclipse at 2:00 on 4 Dec. 773. Ru=39', Rm=15.0', Sep.=11'. The moon was fully

immersed in the umbra and AU records the correct date and it is as Fletcher concluded ‘an undoubted reference’. Henceforth the chronology of AU’s astronomical entries exactly match the year of the corresponding phenomenon.

788 The moon red like blood on the twelfth of the kalends of March - AU 788.
Voyager: A lunar eclipse at 3:30 on 26 Feb. 788. Ru=43’, Rm=16.3’, Sep.=11’. The moon was fully immersed in the umbra making a reddened moon plausible and this was also Fletcher’s identification, while pointing out an error in Mac Carthy (1901, p.140) and rejecting Newton (1972, p.654). Since 26 February equals the fourth kalends of March, AU’s date has corrupted *.iiii.* to *.xii.*

807 The moon was turned to blood - AU 807 + CS 807.
Voyager: Lunar eclipse at 2:40 on 26 Feb. 807. Ru=46’, Rm=16.9’, Sep.=31’. The moon was nearly fully immersed in the umbra and Fletcher favoured this eclipse, notwithstanding his problem with AU’s dates, so it is now a much firmer favourite. Henceforth the chronology of CS’s astronomical entries exactly matches the year of the corresponding phenomenon.

865 A solar eclipse on the kalends of January [1 Jan], and a lunar eclipse in the same month - AU 865 + CS 865 + AC 863 + AF 865 + AI 865.
Voyager: Solar eclipse at 13:40 on 1 Jan. 865. Rs=16.2’, Rm=16.4’, Sep.=2’. Track=N. Atlantic, S British Isles. This eclipse was seen as total on the south coast of Britain and as a deep eclipse all over Ireland and Britain. Fletcher regards this identification as definite and remarked that ‘we have encountered no record except from Ireland’, but his assertion regarding the Irish entries that ‘the manuscript year is always wrong’ is certainly incorrect for AU and implicitly so for AI and CS.
Voyager: A lunar eclipse at 17:45 on 15 Jan 865. Ru=39’, Rm=15.0’, Sep.=24’. The moon was just fully immersed in the umbra and two annals have recorded all the details of both events accurately. The only other record of this eclipse noted by Fletcher is from Germany, in the annals of Xanten.

878 There was a lunar eclipse on the ides of October [15 Oct], the fourteenth of the moon, on the fourth feria [Wednesday] about the third watch[0:00 - 4:00]; and a solar eclipse on the fourth of the kalends of November [29 Oct], the twenty-eighth of the moon on the fourth feria, about the seventh hour of the day, fifteen solar days having intervened - AU 878 + CS 878.
Voyager: A lunar eclipse at 3:53 on 15 Oct. 878. Ru=39’, Rm=14.9’, Sep.=22’.
The moon was just fully immersed in the umbra and 15 Oct. did fall on Wednesday.
Voyager: A solar eclipse at 12:52 on 29 Oct. 878. Rs=16.2’, Rm=16.7’, Sep.=2’. Track=N. Atlantic, N. British Isles, N. Sea. It was seen as a total eclipse in central and northern Scotland and as a deep eclipse in all of Ireland and the British Isles and 12:52 fell within the seventh hour. The lunar dates both accord with an epact of *luna .xxiii.* on kalends January and so all of the data in AU is accurate. Fletcher discusses records of this eclipse from the Anglo-Saxon Chronicle, Regino of Prüm, and annals from Iceland and Fulda, of which only the last compare with these annals’ record for accuracy.

885 A solar eclipse and stars were seen in the heavens - AU 885 + CS 885.
Voyager: A solar eclipse at 9:25 on 16 June 885. Rs=15.7’, Rm=16.9’, Sep.=2’. Track=S. Atlantic, NW. Ireland, W. coast Scotland, W. Scandinavia. This was certainly seen at least as a deep partial eclipse from and near Ireland. If the ‘stars’ in this annal refers to the planets, all five of which were above the horizon at the time of the eclipse, then it is the only reference to the planets in these annals. However, the eclipse occurred when the sun and moon were in Gemini, just 12˚ from the Twins, Castor and Pollux, and the following zero magnitude stars lay in the same field of view: Betelgeuse 22˚ away, Procyon 20˚ away, and Capella 32˚ away. The depth of this eclipse ensured that from totality all of these stars were visible, so there are serious grounds for proposing that the report in AU actually derives from an observation of stars made in totality from Ireland. Fletcher, relying on Schroeter’s track which gives the band of totality as ‘skirting the North-West coast of Ireland’, classifies this as a ‘near total solar in Scotland and N. Ireland’, but relatively small changes in the deceleration of the rotation of the earth would move the track of totality over Ireland, and this annal certainly suggests that the track should be re-examined.

912 A comet appeared. AU 912
Peng-Yoke (1962, p.178) cites from six Chinese sources: ‘15th May 912 “ ... a comet was seen the the west of *Ling-Thai*[Leo]”’ and, since AU’s chronology has been accurate since 773, there is no

reason to doubt this identification. The only other Western record of this comet given by Hasegawa (1980, p.75), is from Egypt.

917 Horrible portents also: the heavens seemed to glow with comets - AU 917.
Neither Peng-Yoke nor Hasegawa record a comet for this year and neither do they record any adjacent years with multiple comets; however Schove (1955, p.134) gives 917 as a year of moderately strong sunspot maximum, so that the reference to a plurality of 'comets' suggests that this is really an observation of repeated aurora. This identification also better fits the sense of the Latin *celum ardere*.

921 A lunar eclipse on the third feria [Tuesday], the fifteenth kalends of January [18 Dec] at the first hour of the night - AU 921.
Voyager: A lunar eclipse at 18:24 on Monday 17 December 921. Ru=44', Rm=16.5', Sep.=22'. On this date the sun set at 16:46 and the first hour ended at about 18:10 so that maximum eclipse therefore occurred during the second hour; the day and date however have clearly been advanced by one day, most probably in the course of adjusting the original lunar date to a new lunar cycle. Fletcher rationalised 'third feria' in terms of ecclesiastical usage but this does not solve the date error.

939 The colour of blood on the sun from the break of day until the middle of the next day - CS 939.
This record is undoubtedly an observation of the plume of the eruption of the volcano Eldgjá in Iceland, which has been extensively documented from acidity, conductivity and basaltic glass shards found in the GISP2 Greenland ice core and from tree-ring chronologies, see Zielinski (1995, p.129-140). From these they deduced a date of 938±4, but their search of historical records failed to disclose any record enabling them to refine this date. *Chronicon Scotorum* now rectifies this deficiency and the reliability of its astronomical observations from 807 forward suggest that 939 is the appropriate year and this, together with the time series of SO_4^{2-} and conductivity given by Zielinski et al. in figure 3 a) & b), suggest the eruption occurred in the spring of 939. The short and specific time interval of approximately 30 hours, 'from the break of day until the middle of the next day', strongly suggests that it is an observation of the initial plume emerging from Eldgjá. Fletcher under 936 interprets reports by Widukind of Corvey of portents observed before the death of Henry I in July 936 to the effect that 'the sun out of doors in an unclouded sky appeared almost nil', as the solar eclipse of 16 April 934, but an observation of Eldgjá's dust cloud transferred back three years to Henry's death seems to us more plausible.

1018 A comet appeared this year for the space of a fortnight in the autumn season - AU 1018+AC 1011.
Peng-Yoke (1962, p.182) cites from two Japanese sources: '3rd August 1018 "... a comet measuring over 20ft appeared in the NW"'. His sources describe it as becoming more intense up to 13th August, but give no absolute duration of visibility; we suggest that, because of the coincidence of AU's year and August being the first month of the Irish season of autumn, there is no doubt but they are identical.

1023 Kalends of January, third ferial [Tuesday], fifth of the moon. A lunar eclipse on the fourteenth day of the January moon, that is, on Thursday the fourth of the ides of January [10 Jan]. A solar eclipse, moreover at mid-day, a fortnight afterwards on the twenty-seventh of the same moon, Thursday the ninth of the kalends [of February ie. 24 Jan] - AU 1023 + CS 1023 + AT 1023 + AC 1023 + AI 1023 + ALC 1023 + AB 1139.
Voyager: A lunar eclipse at 19:54 on 9 Jan 1023. Ru=38', Rm=14.8', Sep.=27'. The moon was substantially immersed in the umbra. In this year 9 January fell on a Wednesday so that it is clear that the annals' assertion that the eclipse fell 'on Thursday the fourth ides of January [10 Jan.]' is a deduction based upon the age of the moon on the kalends of January and the assertion that the eclipse occurred on the fourteenth of the moon. Whoever has made this deduction has not taken account of the fact that the lunar age changed at sunset, so the fourteenth moon commenced at sunset on Wednesday evening and the eclipse followed shortly thereafter. All other details of the lunar eclipse are accurate.
Voyager: A solar eclipse at 12:01 on 24 Jan. 1023. Rs=16.2', Rm=16.8', Sep.=1'. Track=S. Atlantic, off S. coast of Ireland, central England, N. Sea. It was thus seen as a total eclipse in central England and deep everywhere else in Ireland and Britain. The 24 Jan. fell on Thursday, so that all the annalistic details of the solar eclipse are accurate, except that the age of the moon has been scribally

corrupted from *.xxviii.* to *.xxvii.* This dual eclipse is another example of a double portent, cf. 672. The solitary astronomical record from the annals of Boyle appears to be a badly misplaced and corrupt version of the entry which appears in AI 1023.

1039 An eclipse of the sun in this year - AI 1039.
Voyager: A solar eclipse at 10:50 on 22 Aug.1039. Rs=15.9', Rm=15.8', Sep.=2'. Track = S. Greenland, S. British Isles, France, Italy, E. Africa. This eclipse which was deep from everywhere in Ireland may have been seen as annular from the south coast. It is the only observation from Ireland in these annals unique to AI.

1054 A round tower of fire was seen *in the air over Ros Ela* on Sunday the feast of S. George [24 April] *for five hours of the day* - CS 1054 + AT 1054 + AFM 1054.
In Section 5 we suggest that this may be an interpolated record of an observation of the supernova of 1054, whose remains we know today as the Crab Nebula (M1); the only elements of the entry definitely not interpolated are shown in italics. The fullest account of the appearance and disappearance of the supernova is given in the Chinese records, particularly the *Sung hui-yao*; the passage from the *Sung hui-yao* most relevant to this entry in the Irish annals is:
'Originally, in the fifth month of the first year of the period Chih-ho [9 June - 7 July 1054] it had rising in the morning in the eastern heavens guarding T'ien-kuan [zeta Tauri]. It was visible by day, like Venus; pointed rays shot out from it on all sides. The colour was reddish-white. Altogether it was visible for twenty three days.', see Breen & Mc Carthy (1995, p.366-71).

1066 A hairy star, strange, enormous, was seen in the air on Tuesday after Little Easter, at the eight of the kalends of May [24 Apr] with the twenty sixth of the moon thereon. Such was its size and brightness that men said it was a moon, and to the end of four days it remained thus - CS 1066 + AT 1066 + AFM 1066 + AC 1065.
Peng-Yoke (1962, p.184) gives an entry for this apparition of Halley's comet which extends for 18 lines, describing it from its first sighting on 2 April 1066 until, 'the comet and vapour went out of sight after a total of 67 days'. Of these 18 lines, 12 lines are devoted to describing its spectacular appearance over the dates 24-26 April and it is just this interval which is highlighted in the Irish annals' record. Many European chronicles record observations of this apparition[6], however the Irish record is textually independent of all of these and emphasises just the spectacular phase of the apparition; this entry also has textual elements in common with that of 1054.

1133 An eclipse of the sun at the third hour of the day - CS 1133.
Voyager: A solar eclipse at 11:10 on 2 Aug. 1133. Rs=15.8', Rm=16.9', Sep.=3'. Track=N. Atlantic, N. Scotland, N. Sea. Although this *Voyager* eclipse actually falls in the sixth sundial hour, given the accuracy of CS's astronomical entries from 807 forward and the fact that in Irish MSS the number *.ui.* readily corrupts to *.iii.*, this is doubtless the eclipse recorded in CS 1133.

3. Eras of Irish Astronomical Observation

Reviewing these thirty seven different observations it can be easily seen that they fall into two distinct phases as follows; from 442 to 612, with the single exception of the eclipse of 594, all these entries were either certainly or probably borrowed from other non-Irish sources. Three of the items (442, 497, 512) have unmistakenly been borrowed from Marcellinus' chronicle, which source was also used by the Irish annalists up to the eighth century to supply earthquakes and Papal and Imperial successions, see Mc Carthy (1994a, p.66-70); other sources used were the *Chronicon Luxoviense* from Luxeuil in France and

[6] For European references see *Monumenta Germaniae Historica, Scriptores* series **3** p. 180, **5** p. 273, **7** p. 537, **8** p. 22, **34** p. 390 and the *Scriptores rerum germanicarum* series (1891) p. 71, (1894) p. 103, (1917) p. 196; we are grateful to Prof. I. Robinson for locating all of these. See also F.R. Stephenson & D. Clark, (1978) *Applications of Early Astronomical Records*, 11.

material apparently from Spain associated with Isidore of Seville. However by 627 these borrowings cease and the eclipse record of 594 shows clearly that at least by the end of the sixth century the Irish monasteries were recording some astronomical events, and, this conclusion is in accordance with Smyth's finding that the very earliest Irish records of more readily-observed events such as weather extremes, famines and plagues, commenced at about 550.

The second phase runs from 627 to 1133, and the 31 entries over these years are all either observations demonstrably made from Ireland or implicitly so, since no other European textual source can be shown for them, as Fletcher's research demonstrates. Moreover all these observations reconcile either precisely or very closely with the descriptive and chronological details of the phenomena concerned, whenever we can check these. In summary we may say that for the five hundred and six years between 664 and 1133, accurate observation and recording of astronomical phenomena was sustained in monasteries in Ireland, and there is a clear indication that this practice had in fact commenced earlier, at least by 594. A most surprising and unanticipated result is also that, notwithstanding the substantial increase in the level of annual coverage in all of the annals with time, and that some of them including AU come all the way down to the close of the sixteenth century, absolutely no astronomical observations have been recorded after 1133; the contrast in the five centuries before and after this date could not be greater.

The existence of five hundred years of largely accurate records in Table 1 naturally prompts the question as to whether this represents the totality of Irish observations over those years, or is it just a small fraction of the observations that were fortunate enough to make it to the annals? A number of considerations suggest that the latter is the case. Firstly the ten solar eclipses recorded in the annals represent a small fraction of the forty major solar eclipses events visible from central Ireland and with an angular separation of 6' or less detected by *Voyager* between the years 627 and 1133. Secondly we remark the number of minor or inaccessible lunar eclipse events that were accurately recorded, particularly over the eighth century; the lunar eclipses of 691, 718, 734, 753, 763, 773, 788, 807, 865, 878, 921 and 1023 were all either of low magnitude or occurred in the early morning hours or both, and yet they are all substantially accurately recorded. It is difficult to explain this incidence of so many relatively obscure events unless systematic observation was maintained. Thirdly the level of detail which has been often recorded; the lunar eclipse of 921 is the only eclipse recorded for the tenth century, yet the date and time were recorded essentially correctly. If this frequency reflected the level of interest in the phenomena then it seems quite improbable that such details would have been noted and correctly transmitted. Fourthly the fact that, for the apparition of Halley's comet in 1066, only the spectacular days of the apparition were recorded as we can tell from the much fuller Chinese record, but this naturally implies the existence of a longer record in order that the annalist could

select the most spectacular part. Finally, as noted in the discussion for the aurora record and lunar eclipse of 672, there is a decided preference for records of double events in these annals; the years 447, 664, 691, 735, 753, 763, 865, 878 and 1023, ie. nearly 25% of the entries, exhibit dual aspects such as Crucifixion/solar eclipse, aurora/luna eclipse, St. Martin's feast/lunar eclipse and lunar/solar eclipse pairs within the same month. All of this indicates that observations were not admitted to these annals on the basis simply of their objective interest or dramatic content - note the number of deep solar eclipses which were omitted - but rather if in the annalist's judgement the observation constituted a 'sign' or 'portent'.

Of course the context of all these observations was monastic and the explicit references in the annals to religious precepts such as St. Martin's feast and Easter, and implicit references to the Crucifixion (solar eclipse at ninth hour) in themselves indicate the religious light in which these observations were viewed by the annalists. Furthermore the language in which some of the records are couched, viz. 'blood-red moon', 'colour of blood', 'dark sun', 'dragons' as well as explicit references to 'horrible portents' and 'a horrible and wonderful sign', leave no room for doubt but that the Bible provided the specific inspiration and justification for the recording of these observations. Specifically the Book of Revelations provides the principal Christian Apocalypse or revelation concerning the end of time or 'Last Days', and it identifies these by repeated reference to natural and particularly celestial phenomena involving the sun, moon, stars, clouds and storms, dragons and earthquakes which are all used to portend the catastrophes prophesied to occur at this time[7].

From this the basis for the admission of astronomical observations, and indeed terrestrial and meteorological and political observations, to these annals emerges clearly; they were admitted if the annalist considered them possible candidates as signs or portents of the 'Last Days' as disclosed in the Book of Revelations, which in turn explains their predilection for double or multiple 'signs', since this resembled more closely the Apocalyptic vision[8]. This eschatalogical perspective on history and chronology was not an Irish development, but rather a continuation of a tradition found in the fifth century chronicles of Sulpicius Severus from southern Gaul and Hydatius from northern Spain.

Finally we consider the matter of where these observations were made; up to 740 all the annals incorporate a chronicle from Iona and it seems likely that the records of observations up to that year originated there. Between 740 and c. 912 AU, AT, CS and AC incorporate material from the monasteries of Clonard in Co. Westmeath and from Armagh and, given the long history of astronomical observations at the latter site we may well

[7] References to these phenomena are found in all chapters of Revelations except chs. 14-15 and 17-18.

[8] The complete absence of any reference to planetary phenomena in these annals is particularly striking, but understandable, when it is realised that the planets are never mentioned as a portent in Revelations; thus their absence from the annals does not necessarily infer that no planetary observations were made.

suspect it as the site of observation. After c. 912 the monasteries of Clonmacnoise and Durrow, in the centre of Ireland, appear to be the most probable sites for the observations recorded in AT, CS and AC. We next turn to examine two of the annal entries which we consider to be of particular historical and scientific interest.

4. The Solar Eclipse of 1 May 664 and the Synod of Whitby

Two events of the year 664 have left a significant trace on the historical records of Britain and Ireland; Bede in his *Historia Ecclesiastica* relates at length how in this year at the Synod of Whitby Oswy, king of Northumbria, decided that henceforth his kingdom would celebrate the Roman Easter calculated according to a 19-year cycle, rather than the Easter celebrated by the Columban church calculated according to the 84-year cycle of Sulpicius Severus which he had hitherto celebrated. Also in this year we have seen that the Irish annals provide their first accurate record of an Irish observation of a solar eclipse, and similarly the record by Bede in 703 in his *Chronicon Minora* constitutes the first record of a genuine English observation of an eclipse, as was noted by Fletcher. Since both of these events involved the moon it is remarkable that it seems never to have been considered that they were related, but as we shall see there are strong grounds for believing that they were.

The first indication that there may have been something sensitive about this eclipse is that Bede's five records of it in his *Chronica Minora* and *Maiora* and his *Historia Ecclesiastica* consistently cite the correct time but place it on 3 May, which is two days late. Why should Bede, an expert chronologist and whose abbot and mentor Ceolfrid had been a monk at Gilling at the time of the eclipse, repeatedly make such a conspicuous error? Further, why did Bede emphasize this eclipse, remarking in his *Chronica Maiora*[9],

> The following year [ie. 664] an eclipse of the sun occurred which our age remembers, at about the tenth hour on the fifth nones of May [3 May].

What association lay behind his assertion that his 'age' remembered this particular eclipse, a remark underscored by the fact that he himself recorded absolutely no other English eclipse[10] in either of his *Chronica*, or his *Historia Ecclesiastica*? The second indication of sensitivity surrounding these events is that, despite the length of Bede's account of the Synod, he gives absolutely no information as to what events precipitated it, or why it was held at Whitby, a new monastery at the time, rather than one of the older, established monasteries such as York, Ripon, Lastingham or Lindisfarne.

In order to examine more closely the possible relationship between the solar eclipse and the date and the site of the Synod, in 1993 Dr. F.R. Stephenson kindly undertook to compute the track of this eclipse across the British Isles using the results of his analysis of

[9] For Bede's eclipse references in *Chronica Minora* and *Maiora*, see Mommsen (1898, p.313)

[10] The eclipses of 538 and 540 which Bede recorded in his recapitulation at HE V.24, he borrowed from the Mediterranean, see Fletcher in Schove (1984, p. 97-8).

the changing rotational speed of the earth and moon, see Stephenson & Morrison (1982). The result showed that the path of totality crossed Northumbria and Dr. Stephenson concluded that: 'Using a value for Delta T of 4150 sec at AD 664 ... I compute that for Whitby the eclipse would be fully total at 17.3h local time, the solar altitude then being +19 deg. On this value for Delta T, Whitby would lie very close to the central line and totality would last there for about 2.5 min.'. His results for the track of totality were as follows[11]:

Table 2. Track of the solar eclipse on 1 May 664 across Britain according to Stephenson.

	Totality limits ..		Local time	
Longtitude	N. Lat.	S. Lat.	(hours)	Altitude
10˚ W	56.31˚	54.81˚	16.6	25˚
7˚ W	56.05˚	54.56˚	16.9	23˚
4˚ W	55.73˚	54.24˚	17.1	21˚
1˚ W	55.36˚	53.87˚	17.3	19˚

When plotted on a Mercator projection these results indeed show that the centreline of the path of totality passed about four miles north of Whitby (37'W, 54˚ 28'N); this path of totality was about 100 miles wide with the deepest and longest darkness along the centreline which ran WNW to ESE, as shown in Figure 1. Other Northumbrian monasteries and their distance from this estimated centreline are as follows: Hartlepool 4m N., Gilling 17 m S., Lastingham 20 m S., Ripon 38 m S. and York 45 m S, and these monasteries are all associated with individuals who figure prominently in Bede's account of the Synod and subsequent events. A further twelve unamed monasteries founded on grants of land given by king Oswy to the Columban church in Deira and Bernicia in 655, must all have lain either under or near this belt of totality, and Bede disrupts the chronology of his *Historia* to place his description of Oswy's role in the establishment of all of these monasteries immediately before his account of the Synod of Whitby, see Colgrave & Mynors (1991, p.291-3).

To establish a dependence between these events it is obviously necessary to know the order in which they occurred and it is remarkable that, with all the information Bede transmitted concerning the Synod, he omitted to record the date. This question was examined closely by Grosjean (1960, p. 255) and by Abel (1983, p.23), who derived contradictory conclusions; however, they both overlooked the fact that Bede, at the very beginning of Book IV, provided a relative chronology for all the relevant events as follows:

> In the year of the eclipse already mentioned and of the pestilence which quickly followed, Colman, defeated by the unanimous decision of the catholic party, returned to his own people; and Deusdedit, the sixth bishop of the church at Canterbury, died on 14 July.[12]

[11] F.R. Stephenson, personal communications to D. Mc Carthy, 17 Dec. 1993 and 18 Jan. 1994.

[12] Colgrave & Mynors (1991, p.329).

The order of the five events listed here is: eclipse [1 May], pestilence, Synod, Colmán's exile, Deusdedit's death [14 July], and, given both Bede's eminence as a chronologist and his legendary committment to the truth, it would be truly extraordinary if he had listed them anachronistically. Thus the clear implication of this passage is that the five events occurred, in this order, between 1 May and 14 July. Hence the eclipse preceded the Synod and, that the latter was in fact precipitated by the former is indicated by Pope Vitalian's reply to a letter King Oswy wrote to him in 665. Vitalian commenced by acknowledging Oswy's fervent desire for eternal life and continued:

> ...and we know how you have been converted to the true and Apostolic Faith by the shielding right hand of God.[13]

How did Vitalian propose that God's shielding right hand - *dextera Domini protegente* - could effect Oswy's conversion, not, it must be remembered to Christianity, but rather from the Celtic church to the Roman church? Surely it was by God's hand shielding the sun and denying its light to all of Oswy's Columban monastic foundations. This interpretation is further indicated by Vitalian's injunction to Oswy to observe-

> everything delivered by the holy apostles, Peter and Paul, who, like two heavenly lights, illuminate the world, while their teaching daily illuminates the hearts of believers.

Both his explicit analogy with the sun and moon - *duo luminaria* - and his reference to Peter and Paul's 'daily light' is surely intended by Vitalian as an antithesis to the interrupted light directed by God on the monasteries of Oswy's erstwhile Columban foundations[14]. We conclude therefore that the Synod of Whitby was likely held in May or June, in an atmosphere of terror caused by the combination of total eclipse, plague and aurorae, and in the chaos Oswy was frightened into transferring his allegance to the Roman church so that, by 14 July Colmán and his followers had been expelled from Northumbria. It seems clear that Bede eliminated the role of the eclipse in the Synod from his account because he wished to present Oswy's decision as a noble triumph for the 'perfection' of the traditions of the Roman church, *vis-a-vis* those of the Celtic church of the British, Picts and Irish. The same motivation resulted in the redating of the eclipse to 3 May to make it coincide with the Roman lunar calendar. Since it was this eclipse which initiated the whole sequence of dramatic events and resulted in the conversion of all of Anglo-Saxon Britain to the Roman church, we can now well understand why Bede remarked that it was remembered by his age and why he recorded it so emphatically.

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[13] See Colgrave & Mynors (1991, p.318-20) for this and the following citation.

[14] Vitalian also cites with approval Isaiah's words, inferring that they apply to Oswy: 'I, the Lord have called thee [ie. Oswy] in righteousness ... for a light of the Gentiles; to open the blind eyes, to bring out the prisoners from prison, and them that sit in darkness out of the prison house'. In this way Vitalian further reinforces his theme of rescuing from 'darkness' the adherents of the Celtic church, to whom he refers as 'the tares sown by the Enemy throughout your island'.

5. The Supernova of 1054

The excerpts from AT, CS and AFM which we have reproduced in translation in Table 1 under the year 1054, are clearly distinct from all the other astronomical entries in the annals, and a first reading does not readily suggest that they relate to astronomical pheonomena. However their assertion that something fiery was seen in the year 1054 over a certain place on a certain date for five hours in daylight was sufficiently close to the Chinese description of the 'guest star' sighted in early July 1054 as being 'visible by day, like Venus; pointed rays shot out from it on all sides; the colour was reddish-white... altogether it was visible for 23 days', to prompt Dr. Breen to propose in 1994 that this annal entry may preserve part of a report of an observation of the supernova from Ireland. The principal difficulties in the way of such an identification are firstly, that the description of the object as a blazing round tower, and the date of 24 April inferred from S. George's feast in the Irish church, do not readily reconcile with the Chinese record. A second, and at first sight a far greater difficulty, is that these excerpts cited from AT, CS and AFM are all simply the beginning of a much longer passage imbued with an air of high fantasy, reading as follows:

> A round tower of fire was seen at Ros Ela on the Sunday of the feast of S. George, for the space of five hours of the day, and innumerable black birds passing into and out of it, and one great bird in the midst thereof, and when the little birds would enter the round tower they would come under her plumage. They came forth and lifted up the hound that lay amid the town up on high into the air, and they cast him down again, and he straightway died. And three mantles and two shirts they lifted up on high and down again they flung them. Now the wood whereon the birds perched fell beneath them, and the oak whereon the great bird sat was a-tremble with its roots in the earth.[15]

Now the literary quality of this passage alone indicates that it is nearly all interpolated for, as was mentioned in the introduction, annal entries are characterised by their cryptic, detached style in which real events are summarised. In this entry, with the sole exception of the real placename 'Ros Ela', the whole passage has a quality of dramatic, enigmatic fantasy making analysis of it a formidable task. Fortunately the enigma was resolved when Dr. Dáithí Ó hÓgáin of the Department of Irish Folklore, University College Dublin, identified the passage as a medieval account of the Antichrist legend. Knowing this, our procedure is to examine the passage to establish all those elements which derive from the Antichrist legend; these will then be set aside and the remainder of the entry examined and, to accomplish this, we must needs take an excursion into the strange world of Apocalyptic Christianity.

Briefly, in its early form, the Antichrist legend told how just before Jesus' second coming at the end of time, the Antichrist would come as an evil parody of Christ. His arrival would be marked by wars, earthquakes, darkening of the sun and moon, falling stars and many other grim wonders. In form he could appear either as a handsome, talented

[15] This is taken verbatim from W. Stokes' *AT*, p. 287 except for minor textual improvements.

leader, a winged, destructive beast or an all-conquering warrior, and he would be accompanied by a demon horde in various guises who would do his evil bidding. It was foretold that Antichrist would work various 'miracles' in order to deceive the faithful, such as reversing the direction of rivers, levelling mountains and in particular 'miracles' concerning trees such as making their roots flower underground, or simply destroying them along with fishes and beasts. To defend the followers of Christ, the prophet Elijah would return from Paradise and would engage Antichrist, but be killed by him and his body to lie in the city of Jerusalem for three and a half days. Then, with the second coming of Christ, Antichrist would be defeated and Elijah resurrected and, with the true followers of Christ, be brought to the kingdom of God forever. Such in outline are the essential elements of an early medieval version of the Antichrist legend as found for example in the ninth century German poem, the *Muspilli*, see Emmerson (1981, p.96-7).

The first part of this legend was based on the *Book of Revelations,* verses 8.5-13 of which list the terrors marking the approach of Antichrist including thunder, earthquakes, fire, destruction of trees and creatures, falling stars, darkening of the sun and moon and general woe to all earth dwellers. The verses 9.1-11 of *Revelations* then describe the arrival of Antichrist in the form of the angel of destruction as follows:

> And the fifth angel blew his trumpet, and I saw a star fallen from heaven to earth, and he was given the key of the shaft of the bottomless pit, and from the shaft rose smoke like the smoke of a great furnace, and the sun and the air were darkened with the smoke from the shaft. Then from the smoke came locusts on the earth and they were given power like the power of scorpions of the earth... In appearance the locusts were like horses arrayed for battle; on their heads were what looked like crowns of gold; their faces were like human faces, their hair like women's hair, and their teeth like lions' teeth; they had scales like iron breastplates, and the noise of their wings was like the noise of many chariots with horses rushing into battle. They have tails like scorpions, and stings, and their power of hurting men for five months lies in their tails. They have as king over them the angel of the bottomless pit; his name in Hebrew is Abaddon, and in Greek he is called Apollyon [Destroyer].[16]

The relationship between this passage and the annal entry is immediately apparent; in *Revelations* Antichrist in the form of the angel of destruction, Apollyon, and accompanied by a subject swarm of demoniac, battle-ready, tormenting locusts emerges from the smoking shaft of the bottomless pit, which has been unlocked by a fallen star. In the annals the great bird protecting her subject flock of destructive blackbirds emerges from the blazing round tower and immediately embarks on a campaign of death and destruction, and the image of this great bird is identifiable with *Mórrígu*, the goddess of war and destruction in Irish heroic literature. We see also that the other elements of *Revelation's* account, the locusts and the smoking shaft to the bottomless pit have likewise been translated into concepts familiar to Irish medieval monks, viz. blackbirds and round towers. These round towers were lofty, free standing, cyclindrical structures typically about 90 feet high and,

[16] RSv (1966, p. 229).

with timber floors, stairs and fittings throughout, any conflagrations must have certainly yielded a spectacle warmly suggestive of *Revelation's* 'great furnace' belching forth from the shaft to the bottomless pit. The Irish annals record five such conflagrations between 950 and 1171, frequently with considerable numbers of monks trapped inside, so such events were painfully familiar to medieval Irish abbots and monks. The fallen star of *Revelations 9.1,* which unlocks the shaft and unleashes the forces of Antichrist, is itself identified just four verses earlier in *Revelations 8.10* as follows:

> The third angel blew his trumpet and a great star fell from heaven, blazing like a torch.

While there is no explicit reference in the annals' version of this passage to this star, clearly to any medieval mind steeped in the belief of the Antichrist legend, it is there fully by implication, since according to the Biblical prophecy it is this star which unleashes him and his horde. The remainder of this annal entry describing the killing of the hound and the destruction of trees is likewise readily identifiable with the Antichrist legend; the former is an Irish assimilation of the killing of Elijah by Antichrist and leaving his body in Jerusalem and the latter is in accordance with Antichrist's typical power over trees. We have then at this stage identified all of the elements in this annal entry which derive from the Antichrist legend and hence are interpolated; when we remove these we are left simply with two items, the location 'in the air over Ros Ela', and the duration 'for five hours of the day'. These, we suggest, are the only vestiges of the original annal entry, and our next step is to examine these carefully to see whether they could plausibly relate to the supernova of 1054.

We commence with the location cited where the phenomenon was observed, 'in the air over Ros Ela'; Ros Ela is a well attested placename in Ireland and it has been identified by O'Donovan, in his edition of AFM, with the modern townland of Rostalla in County Westmeath. These townlands are the oldest and smallest administrative units of land in Ireland, far predating the Norman invasion in the twelfth century. In the case of Rostalla it consists of 272 statute acres laying in very flat terrain with a gentle slope upwards to the north-east, typically rising 100 feet in three miles. As such there is absolutely nothing on Rostalla townland which can be identified in the field from more than two or three miles away. However it does lie just two miles to the north-east of the site of Durrow Abbey, a sixth century monastic foundation of S. Columcille which flourished as a centre of learning and the compilation of books and annals up to its conversion to an Augustinian abbey sometime after 1140. From Ireland the supernova of 1054 was seen rising on a bearing of 53˚ and when this bearing is plotted from the site of Durrow abbey it is found to pass clearly through Rostalla townland and virtually directly over the most substantial habitation site in the area, a moated medieval rampart on the southern margin of Rostalla townland. Thus the proposition that a *cloictheach tinnedh* ie. implicitly a 'great star ... blazing like a torch' was seen over Ros Ela, is completely plausible if we hypothesize that an observer was located at Durrow abbey and was recording a sighting of the supernova rising in the

early hours of the morning in July 1054. Moreover it should be noted that if this observation were to have been made in April, as the reference to George's feast might be taken to suggest, then it would have been an evening object setting on a bearing of 360˚-53˚=307˚, and consequently nowhere near Ros Ela. In this way we see that the reference to Ros Ela, slight as it may be, when combined with the topological and historical information of the site, is in concordance with the date provided by the Chinese and Japanese records.

Next we turn to examine the second vestige of the original entry, viz. that the object was seen "for the space of five hours of the day"; the appearance of the words *do ló*, "in the day" in AT, the oldest manuscript, is unique and since we do not normally experience difficulty making observations in daytime, it surely points to some unprecedented observation. Taken with the information from the Chinese records that in this year the supernova was visible in daytime for 23 days, it seems to us that this detail alone suggests strongly that we do have here a partial record of an observation of the supernova. If this hypothesis be accepted, then in one respect this record exceeds the Chinese, inasmuch it specifies a duration of daytime visibility thereby inferring a minimum of brightness, whereas the Chinese account gives no indication as to the daily extent of visibility. Over the last decade B. Schaefer has constructed and validated a considerable number of astronomical visibility models, which he has summarised in Schaefer (1993). In order therefore to test the hypothesis that the object which was observed 'for the space of five hours of the day' could refer to the supernova, Schaefer's equations nos. 9, 10, 34a, 14 and 15d, which define the threshold magnitude m_{th} of a bright point object at zenith angle Z and angle ρ from the sun, which itself is at zenith angle Z_{sun}, and with extinction coefficient k determining the clarity of the atmosphere. The simplified result is:

If $f(\rho) = 10^{5.36}[1.06+\cos^2\rho] + 10^{(6.15-\rho/40)} + 6.2\times10^7\times\rho^{-2}$

then $m_{th} = 8.88 + k(\sec Z_{sun} - \sec Z) - 2.5\times\log[f(\rho)\times(1-10^{-0.4k\times\sec Z})]$

Breen and McCarthy (1995, p.373) have shown already that 4 July is the most likely date of the first Chinese observation, and so the date of maximum brightness must have fallen within the 23 days after that date. Thus for the dates 4, 9, 14, 19, 24 and 29 July 1054 the angles Z, Z_{sun} and ρ were obtained from *Voyager* at one hour intervals as viewed from the location of Durrow abbey; a value of extinction coefficient k=0.31 was chosen from Schaefer's Table 4, this being the value for Boston and Athens in the summertime, and hence typical of maritime, near sea-level situations. The results of this simulation are shown below along with sunrise times at Durrow, and all times are UT.

Table 3. Threshold magnitudes m_{th} for SN1054 seen from Durrow abbey from 4-29 July 1054 against Universal time. Magnitudes in bold are seven hours after sunrise.

	Sun		Threshold magnitudes m_{th} from 6:00 to 14:00								
Date	rise	ρ	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00
4/7	4:11	36.0˚	-3.7	-4.0	-4.1	-4.2	-4.2	**-4.3**	-4.4	-4.5	-4.8
9/7	4:18	40.8˚	-3.4	-3.8	-3.9	-4.0	-4.1	**-4.1**	-4.3	-4.5	-4.7
14/7	4:24	45.6˚	-3.1	-3.6	-3.8	-3.8	-3.9	**-4.0**	-4.2	-4.4	-4.7
19/7	4:31	50.4˚	-2.8	-3.4	-3.6	-3.7	-3.8	-4.0	**-4.1**	-4.4	-4.8
24/7	4:39	55.2˚	-2.5	-3.2	-3.5	-3.6	-3.7	-3.9	**-4.1**	-4.4	-4.8
29/7	4:47	60.0˚	-2.1	-3.0	-3.3	-3.5	-3.7	-3.8	**-4.1**	-4.4	-4.9

Our three sources AT, CS and AFM all agree that observation continued for five hours but it must be taken into consideration that these are monastic and hence sundial hours; in early July these are of duration about 1h. 24m. of clock time, so that five sundial hours equal about seven clock hours. Therefore in Table 3 above we have highlighted in bold print the brightness implied by Schaefer's model for a duration of seven hours from sunrise, rounded to the nearest hour. As can be seen a minimum brightness of -4.0 must have been achieved if the supernova was to have been observed for seven clock hours between 4 and 29 July. This *minimum* brightness compares well with the *maximum* brightness of -5 deduced originally from the Chinese records by Mayall and Oort (1942, p. 98-9), and even more closely with recent estimates of -4.0 cited by Moore (1992, p. 151). Thus we see that this cryptic record of the duration of an observation in the Irish annals is in concordance with the assertion in the Chinese records that 'the guest star ... was visible by day like Venus ... altogether it was visible for twenty three days'. Moreover we may remark that to monitor a point object in the daytime sky for seven hours until it disappears from visibility would be a major observational achievement, and could only be accomplished by very experienced, disciplined observers. This inference is likewise in concordance with our deduction in section 3 concerning the detailed character of monastic astronomical observation.

Given the extremely cryptic character of the vestiges, 'in the air over Ros Ela' and 'for five hours of the day', it will never be possible to prove conclusively that they refer to an observation of the supernova of 1054. That said, the fact that they appear under the year 1054 in annals with a long tradition of recording astronomical observations, and in an interpolated passage which is predicated on the appearance of 'a great star ... blazing like a torch', and that they fit appropriately all the details known concerning the supernova from Chinese and Japanese sources, obliges us to conclude that, if they do not refer to this supernova, then this is a most remarkable coincidence.

6. Conclusions

The Irish monastic annals preserve cryptic but accurate descriptions and chronological records of astronomical events from the fifth to the twelfth centuries; while in the first two centuries the records are mostly borrowed from mainland European sources, from 627 to 1133 the records are all of observations made from or near Ireland. Considering the distribution of the records, it is clear that lunar eclipses were subject to special interest in the eighth century, but in terms of totals however, apart from the peak in the eighth century there was a fairly uniform rate from the seventh to the eleventh century, followed by a decline until they cease absolutely after 1133, despite that fact that the annals continue in some cases until the seventeenth century with greatly increased coverage.

Examination of this astronomical material has resulted in new information relating to a number of events; we have shown that the path of totality of the solar eclipse of 1 May 664 passed over the monasteries founded by king Oswy in the preceding decade as part of his support for Iona's mission to Lindisfarne. Re-examination of Bede's account of events and pope Vitalian's letter to Oswy strongly suggests that it was this eclipse which precipitated the Synod of Whitby and frightened Oswy into switching his allegiance to the Roman church. Next, the annals' record of the solar eclipse of 885 has been shown to provide good reason to consider that its path of totality may have passed over Ireland. Next, the record in CS at 939 and the accuracy of its other astronomical material at this stage, allows the date of the erruption of the volcano Eldgjá in Iceland to be narrowed from the previous estimate of 938±4 down to the spring of 939. Finally the heavily interpolated entry in AT, CS and AF at 1054 has been shown to preserve vestiges which we suggest may be the remnants of an observation of the supernova of 1054. These vestiges are in concordance with both the date of early July 1054, recorded in the Chinese and Japanese chronicles for the first sighting of the supernova, and the peak brightness of at least magnitude -4, as had also been previously inferred from the Eastern records. If this hypothesis is accepted then these annals provide further, independent, evidence that the claim by Guideboni et al.(1992, p. 24-35 & 1994 p. 623-7) that entries in a Flemish and a Roman chronicle, relating to the death of pope Leo in April 1054, demonstrate that SN1054 was first sighted on 11 April 1054, cannot be accepted[17].

In conclusion we may observe that the evidence we have presented here demonstrates that disciplined astronomical observation and recording was sustained in some at least of the Irish monasteries from the sixth to the twelfth centuries, showing that the scholarship of the "land of saints and scholars" must be understood to include the careful study of natural phenomena, as well as biblical and literary disciplines[18] .

[17] Breen & McCarthy (1995, p. 375-6) had already shown, by collation with the Chinese and Japanese sources, that this thesis of Guideboni et al was unsustainable.

[18] The authors would like to record their grateful appreciation to Dr. Paul Murdin for his very constructive criticism of the first draft of this paper.

7. References

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