Jupiter Comet Watch Program

ABSTRACT

This project arises out of a probability that the planet Jupiter will entertain a visitor in the form of the comet 1993e (Shoemaker-Levy).

The consequences of this encounter, according to present calculations, involve a cometary train impact on the planet Jupiter between July 16.81UT-22.3UT, 1994. This possibility at present is estimated at 99%.

What I am attempting to accomplish with this program is to gather visual observers, astrophotographers (including individuals who possess CCD imaging capabilities), and radio astronomers to assist in this venture. It then will be the hope of this endeavor to detect any changes, anomolies, or features on the planet's surface that may result from this encounter.

The main intent of this program is to collect and collate any or all data and present it to the astronomical community. (all participants will be given due credit for their contributions)....All observers are welcomed...of course, *a preference is for individuals who will see this project to the end, if and when a commitment to join is acknowledged.*

Key words: Jupiter, comet 1993e, impact, observers.

FORWARD

The Jupiter/Comet Watch program will attempt to provide the tools necessary for the observer to study the planet Jupiter in order to determine wheather any new features, events, or anomolies are a direct consequence of the impact with comet 1993e (SL-9) and can also act as a comprehensive guide to basic monitorings of the planet Jupiter.....These tools include:

*A visual and descriptive nomenclature of the planet Jupiter.
*Various observable features (18 thumbnail renditions) of the planet Jupiter.
*A total of 5 observing forms for monitoring the planet.
*A program of observation.

All visual observers are welcomed, as well as astrophotographers, (CCD imaging) and radio astronomers.

THE PLANET JUPITER [1,2]

Diameter:	Rotation Period: 9.842 hrs
Equatorial: 142,800 km	Density: 1.32
Polar: 134,200 km	Escape Velocity: 59.6 km/sec
Inclination: 3.12 degrees	Volume (earths): 1,323
Reciprocal Mass: 1,047.355	Surface Gravity: 2.69
Mass (grams): 1.899x10^27	Mean magnitude: -2.3
Geometric Albedo: 0.52	

The planet Jupiter is divided into various Belts (dark) and Zones (bright).

SEB- South Equatorial Belt. Prominent belt immediately above (South of) the Equatorial Zone. Often seen separated into North and South components.
STB- South Temperate Belt. Immediately South of the SEB. The Red Spot frequently interacts with this belt, especially with the many white ovals which appear on its southern edge.
SSTB- South South Temperate Belt- South of the STB. There is little activity here.
EB- Equatorial Belt- This belt is rarely seen, and is probably composed of the connected tops of many loops and festoons which are found in the Equatorial Zone. This belt, if it is a belt, is unstable and very elusive.
NEB- North Equatrorial Belt. Prominent belt immediately below (North of) the Equatorial Zone. Often seen separated into North and South components. It is almost always the most prominent marking on the planet.
NTB- North Temperate Belt. Immediately North of the NEB. This belt usually contains many dark knots and light streaks.
NNTB- North, North Temperate Belt. North of the NTB. There is little activity here.
In general, the Northern Hemisphere of the planet is not as active or interesting as the southern one.
EB- Equatorial Zone. The most prominent zone. It spans the middle of the planet, and contains many delicate features.
STrZ- South Tropical Zone. Prominent zone immediately above (South of) the Southern Equatorial Belt. This zone is famous as the home of the Great Red Spot.
STZ- South Temperate Zone. Immediately South of the STB. Though this zone is usually placid, the light ovals of the STB project into it, producing many intricate patterns and interactions.

SSTZ- South, South Temperate Zone. South of the SSTB. There is little activity here.

EZ- Equatorial Zone. The most prominent zone. It spans the middle of the planet, and contains many delicate features.

NTrZ- North Tropical Zone. Prominent zone immediately below (North of) the North Equatorial Belt.

NTZ- North Temperate Zone. Immediately North of the NTB.

NNTZ- North, North Temperate Zone. North of the NNTB.

SPR- South Polar Region. The dark "Polar Cap" of the planet. Very little observable change occurs here, but occasionally small light or dark spots appear, especially near the northern edge.

NPR- North Polar Region. Immediately North of the NTB. Similiar to the SPR, but less active.

LIMB DARKENING: is not usually noticed by visual observers, yet it is an important aspect of the planet's appearance. Limb darkening appears as a slightly darker crescent-shaped border to the planet's disk, located on the limb opposite to the Sun. When prominent enough to be noticed, it gives a "3-D" effect. (NOTE- "By another definition, this is the effect of the absorption of light by a planet's (or star's) atmosphere, and the whole limb, 360 deg. around, is not as bright as the center of the planet. You can sometimes see the effect in high contrast photos of Jupiter, which shows it having a jagged edge instead of a smooth one"....Steve Edberg)

RS- The Great Red Spot. Slightly larger than the earth, the Red Spot is the planet's most interesting feature. It varies in intensity from a dark brick red to a pale rose color. Occasionally some structure is visible within the spot. At other times it disappears for months, or even years. The spot usually appears as an appendage hanging from the northern edge of the STB.

RSH- Red Spot Hollow. The hollow is an oval which is slightly larger than the spot. The spot lies within it, and when the spot is in its quiescent phase, only the pale white hollow is seen. Sometimes the hollow is bordered by a darker swirl of clouds.

LONGITUDE SYSTEMS: Two longitude systems are used by the visual observer:
System I- This system is used for observations on the equatorial region of the planet. It extends from the southern edge of the northern component of the SEB to the northern edge of the southern component of the NEB. It includes the Equatorial Zone. System I has a rotation of 9h 50m 30.003s.
System II- This system is used for the rest of the planet. System II has a period of 9h 55m 40.632s.

Central Meridian- The central meridian is the imaginary point which passes through the center of the disk in a north, south direction.

OBSERVABLE FEATURES OF JUPITER[1]

OBSERVING FORMS

The 5 observing forms provided with the program are intended to provide observers of all sizes of telescopes with a progressive and increasingly detailed format with which to indicate any noticeable anomolies they might observe on the planet's surface as a result of the proposed impact. In the interim these forms will and can also act as a personal observing program to study the surface of the planet Jupiter to gain an understanding of "what actually goes on " the surface of the planet....

As you will notice all 5 forms are identical in circumference.....a transparent overlay of the chart labeled "Jupiter Nomenclature" is encouraged by the participant, and can be used on any or all forms to precisely determine what zone, or belt a particular observation is made. A log on each chart has been added so the observer may more accurately describe what appears on the surface. In addition tick marks have been inserted at the equator that *roughly* indicate ~10 degree increments for estimating more precisely the locations of observed features. (the curvature of the disk will further distort longitude as they approach the two polar regions, this mode is just a general reference to assist the participant)

Form A- This form is a basic form for general observation of the planet Jupiter. It is separated only by the central meridian, which is the reference point most reports will be based (see next section). In addition this form was intended for those with smaller telescopes, as their ability to acquire deeper detail will be somewhat limited, and the scaled image will be smaller. Of course, any form may be used with any aperture scope.

Form B- This form is exactly like form A, with the exception it is divided into 4 components for folks with medium aperture scopes. As more detail with larger scopes becomes apparent I believe it prudent to be able to have the ability to be more precise in determining the positioning of observed features.

Form C- This form is for the owners of large aperture scopes and astrophotographers (CCD imagers are included and would be a welcomed addition to the program). The form is divided into 16 sections so the viewer can be certain of locating the precise position of a particular feature, with usage of the previously mentioned transparency of the Jupiter nomenclature form.

Jupiter Observation Form- This form will be the final form that is sent to either the ALPO Jupiter Recorder[3] (We are working with A.L.P.O. on this venture), a section leader or to me. This form is identical to the "Nomenclature form" only it has none of the descriptive clutter. (Note: a copy of all observations (positive or negative) should be sent to S.Lucas during the impact window. These observations will then be compiled into a Jupiter Comet paper to be made available to all participants after the event.)

This form may have artistic renditions of visually or photographed features, and/or anomolies gracing them, or letter designations of the above 18 "Observable Features of Jupiter" at the position and time they were observed.....*it is stressed that exact UT times be used in reporting features.....this due to the rapid rotation of the planet so a precise jovian longitude can be noted.*

For astrophotographers do not send your photo's unless you have copies, or unless something extremely extraordinary is noticed, in which case a report to the Central Bureau or professional astronomers would be of more paramount importance...but do send us a FORM!

The observing forms are pretty much self-explanatory: The name of the observer, The size of scope, along with the magnification employed are urged along with any filters that are used (blue and green bring out subtle details not otherwise noticed without a filter). Seeing (1-10 bad-good), a check mark in the SCT section of the form will indicate that the observation was made with an SCT scope...thus the observation can then be viewed with the form flipped face down this will assist in maintaining homogeniety with other observations. The date of the observation, plus the Universal Time and Julian Day (if possible). The Location Section should indicate your location in coordinate format (if possible), and the time zone and weather Daylight Savings time is used in your locale.

THE PROGRAM

The Jupiter Comet Watch program is initially an observing project to determine if any noticeable features will appear on the surface of Jupiter as a consequence of the cometary impact . Some of the observational techniques that an observer will use in actually monitoring the planet Jupiter will be touched on only briefly in this section. This will then give the participant a basic understanding in which to conduct his/her observations. Further reading or contacting The Association of Lunar and Planetary Observers (A.L.P.O) [Jupiter Section][3] is suggested in order to gain a more detailed and comprehensive observing critique.

It might be well to mention here: *that waiting a week or so before the event to get to know and observe the planet Jupiter...will not make deciphering your observations an easy task...so it is urged that the participant gets out and examines the planet well in advance of the proposed event to get accustom to what features and details are evident on the planet's surface.*

In observing the planet Jupiter one of the **most important** factors to remember is that the central meridian (An imaginary line running thru the center of the planet in a north/south line) is the method of choice in determining precise locations of various features, or anomolies (in our case). This plus noting the exact time of the observation will make locating any sighting much easier, due to the rapid rotation of Jupiter (1/10th. of the visible disk of the planet spins in just a 20 minute interval, or 1 degree in less than 2 minutes [0.604° in one minute, 9.06° in 15 minutes, and 36.27° per hour]), plus the chance of many features being present on the planet's surface at the same time.

Noting a particular feature as it crosses the central meridian, and careful determination of which belt or zone the sighting is made will be a determining factor in pinpointing any suspected consequence of the impact. If the sighting just turns out to be a normal Jovian feature then you have added an observation that might assist Jupiter Watchers in their observational programs[3] .

As mentioned earlier if you are not artistic (like myself) you might want to indicate features taken from the Observable Features Chart with the letter of that feature and an arrow, or notation pointing to the area where the feature is located. If you choose you may sketch planetary details on the forms provided.

If something extraordinary is spotted contact your section leader or myself *immediately!*, we will then attempt to verify the sighting and contact the Central Bureau and/or professional astronomers so that the anomoly may be monitored on a larger and more detailed scale (all discoveries will of course be credited to the observer making the observation).

It is also important to recognize the terms Preceding, and Following....Preceding indicates the feature is moving towards the central meridian (-), and Following indicates it is traveling away from the central meridian (+). This in case you happen to spot a suspect feature that is impossible to follow to the central meridian for an accurate timing, or has drifted away from the central meridian. However, attempt to follow up on the observation by noting other reference features, plus the *exact time,* so that a second observation can be attempted. A handy reference to remember is that the Red Spot, or Red Spot Hollow are located on the southern part of Jupiter.

Use the ~10 degree tick marks for observations not able to be timed at the central meridian as a last resort. Due to fact that they are not the strongest point of this program due to disk curvature at the points away from the equator, but may be used to *approximate* longitudes. To further approximate longitude, connect tick marks to S/N poles following planet curvature.

The Log Section is pretty much straightforward.....note feature numbers as they appear in your observing session (observable features, or new anomolies), and the UT time that they crossed the central meridian, a brief description of the object observed. The location.....which belt, or zone, and if the object is North [n], or South [s] of a particular zone or belt, use abbreviations when possible, also use preceding and following designations for objects to the right or left of the Central Meridian. And finally if you use a computer program similiar to the excellent program used as reference for this program,[2] you will be able to pinpoint the exact longitude of your observation, or leave this section blank and it will be figured out at the time your observation is received.[1,4]

WHAT TO LOOK FOR……

No one can be certain what the consequences of the proposed impact will have on the planet Jupiter. We certainly can theorize what could possibly happen if a comet were to impact the earth....but Jupiter....that's anybody's guess! Thus we can only observe and watch Jupiter and the surrounding area to gain an insight into possible anomolies that may result.

The program above, I believe is a fairly comprehensive one in viewing the planet's surface for any changes, however will we be able to determine if something out of the ordinary is a direct consequence of the impact? No one knows that for certain!

Other possible avenues to approach the question is to watch the moons of Jupiter for any changes in their amplitude.

Keep an eye on the limb of Jupiter, and the halo surrounding the planet for any increase in brightness....this may better be accomplished with astrophotography and/or CCD imagary.

The approach of the comet is theorized to approach the planet from the backside...we probably will not see any impact per se, only results or features caused by the intruder.....MAYBE! That is why it is recommended that observers monitor the surface features of Jupiter well in advance of the target date, to possibly observe some spurrious event. It might also be noted that the comet is approaching Jupiter as a train (21 separate pieces).....thus features at impact might cause a chain type anomoly on the surface to appear? (pure speculation, of course)

ASTROPHOTOGRAPHY

I must admit I do not possess the "hands-on" information to direct a photographic program, however I would like to make a few suggestions....

I would begin by making various photo's at appropriate focal lengths, using select emulsions in order to obtain a setup suitable in displaying the planet's features, such that any changes or new anomolies can be detected. Usage of filters, including pass-band filters is encouraged...experiment! Perhaps one or more of you might have some suggestions....I am always willing to accept input, or feedback.

The optimum period for beginning photo's would be approx. 1 week before, and 2-3 weeks after the proposed impact window.

I would also suggest photographing the limb of Jupiter, and the halo around Jupiter to see if anything not detectable in visual wavelengths, might be visible on film. The moons of Jupiter, might be another interesting area to watch.

RADIO ASTRONOMY

This is another subject that is unknown to me....perhaps there is an ongoing amateur program involving radio astronomy and the planet Jupiter? Any assistance along these lines would be greatly appreciated.

TIDBITS

Comet Shoemaker-Levy (1993e) orbital elements: As of Nov. 22, 1993[5]

T= 1994 Apr. 1.3226 TT Peri= 355.1307
e= 0.206613 Node= 220.9658 (2000)
q= 5.382476 A.U. Incl= 5.7864

a= 6.784178 A.U. n= 0.0557774 P= 17.670 yrs

Information concerning the event and/or the comet coordinates will be for epoch 2000 and will be for Universal time.

TRAIN IMPACT PROBABILITY:[6,7]
COMET SHOEMAKER-LEVY 9 COLLISION: Fragment Impact Updates:
From: John Spencer (Lowell Observatory); To: Glenn Orton (IJW) (International Jupiter Watch)

SATELLITE REFLECTOR AVAILABILITY:
Here's an update to the table I sent out this morning, giving the new predictions for SL9 fragment impact times. I have now added the orbital longitudes of the satellites at each impact, and their likely suitability as reflectors of the impact flashes.

In the table, a "+" next to the orbital longitude means that the impact will be visible from the satellite (I'm assuming the impacts are 20 degrees past local midnight on Jupiter). Longitudes near the ends of the visibility range will be less useful as the phase angle of the reflected light will be high. A "*" means the satellite will be visible in eclipse, allowing higher sensitivity observations, and an "o" means it will be occulted by Jupiter. Timing uncertainties are still too large to predict eclipses and occultations at impact times with certainty, though. I've included Callisto (J4) for completeness but it's likely to be too far out to be useful- the same may be truefor Ganymede (J3).

Nucleus Designation		UT date of impact (July)			Satellite Orbital Longitudes (degrees past superior conj.)				
Jewitt DPS	Sekanina abs.	Fitted Preprint	Time	IAUC 5906	Brightness Index	J5	J1	J2	J3	J4
21	A	16.81		1	194	340+	103+	75+	35+
20	B	17.08		1	25*	34+	130	89+	41+
19	C	17.27		1	168	74+	150	99+	45+
18	D	17.46		1	304	112	169	108	49+
17	E	17.61	17.6	2	49+	142	183	115	52+
16	F	17.98		2	320+	218	221	134	60+
15	G	18.29	18.3	2	184	281	253	150	67+
14	H	18.79	18.8	2	183	22+	03+	175	78+
13	J	19.08		1	37+	83+	333+	190	84+
12	K	19.41	19.4	2	272	149	6*	206	91+
11	L	19.91	19.9	2	271	250	57+	231	102+

10	M	20.24		1	152	318+	90+	248	109+	
9	N	20.40		1	265	350+	106	256	112	
8	P	20.61		2	58+	33+	128	266	117	
7	Q	20.82	20.8	3	207	75+	149	277	121	
6	R	21.21	21.3	2	135	156	189	297+	130	
5	S	21.63	21.6	2	78+	241	231	318+	139	
4	T	21.73		1	150	261	241	323+	141	
3	U	21.91		1	281	298	260	332+	145	
2	V	22.19		2	117	353o	287	345+	151	
1	W	22.33	22.3	2	219	22+	302+	353+	154	
Uncertainties:		0.1	0.1		72	20	10	5	2	

As before, the "brightness index" subjectively rates comet fragment brightnesses, 3 being brightest. Relative timings of impacts are taken from the Sekanina, Chodas, and Yeomans preprint, with absolute times adjusted for best fit to the IAUC 5906 times. Only Io is suitably placed for the impact of the brightest fragment, (7 or Q), and even Io's location isn't great unless theimpact is at the early end of the uncertainty range. There are several possibilities for eclipse observations but none are certain yet.

Predicted Impact Parameters for Fragments of P/Shoemaker-Levy 9

These predictions are based on our new orbit solutions for nine of the fragments (those whose rows are complete in the following table). The recent astrometric data from Jim Scotti are included in these solutions (data through Dec. 14). The impact times have moved 1.65 d earlier than in our previous set of predictions, and are now uncertain by only a few hours. The impact times of those fragments without orbit solutions were obtained by fitting the relative impact times from our preprint (Sekanina, Chodas, and Yeomans) with predicted impact times of the other 9 fragments. Note that the impact locations on Jupiter have moved closer to the planet's morning terminator, and are now within 10 deg of the
nearside hemisphere as viewed from the Earth. Although the prediction for fragment R puts it very close to the limb, this is probably due to the fact that its orbit is poorly known, since it has the least amount of astrometric data.

Fragment	Impact Date (July)	Jovicentric Latitude (deg)	Meridian Angle (deg)	S-F-J (deg)	E-J-F (deg)
A = 21	16.82				
B = 20	17.08				
C = 19	17.28				
D = 18	17.47				
E = 17	17.58	-43.85	62.28	72.71	100.09
F = 16	17.98				
G = 15	18.31	-43.72	65.94	75.13	97.53
H = 14	18.78	-43.46	67.22	75.92	96.66
J = 13	19.08				
K = 12	19.41	-43.56	69.08	77.24	95.31
L = 11	19.92	-43.86	68.63	77.02	95.57
M = 10	20.23				
N = 9	20.38				
P = 8	20.59				

Q = 7	20.78	-44.01	68.51	76.98	95.62
R = 6	21.27	-42.69	75.08	81.25	91.05
S = 5	21.60	-44.84	66.47	75.86	96.89
T = 4	21.71				
U = 3	21.89				
V = 2	22.16				
W = 1	22.29	-44.40	69.42	77.72	94.89

Notes:
1. Two fragment designations are given: the letter designation is that used in our preprint (Sekanina, Yeomans, and Chodas); the numerical designation is that used by Jewitt. Q=7 is the brightest.

2. The meridian angle is the Jovicentric longitude of impact measured from the midnight meridian towards the morning terminator.

3. Angle S-F-J is the Sun-Fragment-Jupiter angle at impact; values less than 90 deg indicate a nightside impact: all impacts are on the nightside.

4. Angle E-J-F is the Earth-Jupiter-Fragment angle at impact; values greater than 90 deg indicate a farside impact: all impacts are on the farside as viewed from Earth.

5. More decimal places are given than are significant.

6. These predictions will be improved as additional astrometric data are included in orbital solutions. (D.K. Yeomans and P.W. Chodas, (93/12/17)

JOVIAN MOONS VISIBLE DURING IMPACT WINDOW [8]:

This section will deal with visibility of the Jovian moons during the impact window:

Jovian Moon Revolutions:
Io- $1^{d}\,18^{h}\,28^{m}$
Europa- $3^{d}\,13^{h}\,14^{m}$
Ganymede- $7^{d}\,3^{h}\,43^{m}$
Callisto- $16^{d}\,16^{h}\,32^{m}$

Here is a time-frame visibility chart for each of the Jovian moons.(where the moon will be behind the planet, but visible to earthbound observers and in a good position to notice any moon brightenings, if they occur at all?. All times are UT. (Also see ASTRONOMY magazine, Jan., 1994, pg.66 for a comprehensive graph of Jmoon observability)

Io: Visibility Window Begins:	Visibility Window Ends:
16d 19.15h (Author's estimate[SHL*]) >	17d 08.75h
18d 14.9h	19d 08.2h
20d 09.4h	21d 02.6h
22d 03.9h	22d 21.1h
23d 22.4h	24d 15.6h
25d 16.8h	26d 10.1h
Europa: Window Begins	Ends:
15d 13.45h (author's estimate[SHL*]) >	16d 20.75h
19d 04.2h	20d 12.25h
22d 17.5h (author's estimate[SHL*]) >	24d 00.75h
Ganymede: Window Begins	Ends:
14d 21.1h	18d 04.8
22d 01.0h	25d 08.7h
Callisto: Window Begins	Ends:
14d 00.8h	22d 01.3h

(*)=Usage of GALSAT Program (Danny Bruton; Texas A&M Univ.)

(Note: A method of determing any brightness occuring on a particular moon could be by "trailing the moon"[via astrophotography, leaving drive-off] over a particular length of time).

JUPITER AND MOON RISE TIMES[(9)], AND LOCATION

All positional solar system data will use the terra coordinates **- 88.00W, +41.30**.

Jupiter:	**Rise**	**Transit**	**Set**
July 18th. 1994-	14:19 (CDST)	19:35 (CDST)	00:53 (7/19)
July 21st. 1994-	14:08	19:24	00:41 (7/22)
July 24th. 1994-	13:57	19:24	00:30 (7/25)

Locational coordinates at time of proposed impact:

July 18th. 1994- (2000) $14^h13^m1.88^s$, $-12^o11'17.5"$(Virgo)
July 21st. 1994- $14^h13^m53.4^s$ $-12^o14'53.4"$
July 24th. 1994- (7/23) $14^h14^m12^s$ $-12^o18'53"$

Moon:	**Rise**	**Location**
July 18th. 1994-	16:42	(not a factor)
July 21st. 1994-	19:14	18^h29^s, $-19^o39'$ (96.5%)
July 24th. 1994-	21:05	21^h17^s, $-10^o28'$ (97.5%)

EPILOGUE

In the universe, and indeed in this world....there are many certainties and, of course uncertainties. People like stars are born...and eventually expire. Jupiter is a certainty, as is the comet Shoemaker-Levy....With this in mind we as amateur astronomers are attempting to find out if there will be any phenomena that will be attached to this event. Even if nothing occurs or is detected then organizing a group of people to rally under a "common banner" is worth the effort to me. If something does happen then we will possibly gain a ringside seat for the show of a lifetime. It is again stressed that observations should be sent to your section leader or to me on a regular basis, perhaps every week or so when the planet is visible for observation. Remember a 15 minute observation is better than no observation at all.....Good Viewing, and above all good luck.

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(6). Micheal A'Hearn BBS
(7). Glenn W. Orton, (IJW)(International Jupiter Watch , Atmospheric Team Chairman) E-Mail List
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Steve H. Lucas: Updated (12/31/93)