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# Predictions of the mutual events of the Galilean satellites of Jupiter occurring in 2009–2010

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**ABSTRACT**

*Aims.* Mutual occultations and eclipses of the Galilean satellites of Jupiter will occur in 2009–2010. This paper provides predictions of these events as well as useful information for their observations. Such events are uncommon, since they only occur every 6 years when the Earth and the Sun pass through the common orbital plane of the Galilean satellites. The present dynamical models of motion of the Galilean satellites include the effects of the internal structure of the satellites on their motion. Only accurate observations such as mutual events may fit the parameters depending on the internal structure.
*Methods.* For these predictions, we used the best theoretical models of the motion of the Galilean satellites since the prediction of events is very sensitive to the accuracy of the relative calculated positions of the satellites.
*Results.* Therefore, we encourage professional and amateur astronomers to join the networks of observers in order to get as many observations as possible. Data on the predictions of the events and interactive software for their visibility are available on the web server of the IMCCE (www.imcce.fr/phemu09).

**Key words.** planets and satellites: individual: jupiter – eclipses – occultations – ephemerides

## 1. Introduction

Recent results on the accelerations in the longitudes of the Galilean satellites have shown how accurate astrometric observations may be good help for the modeling of the internal structure of the satellites (Lainey et al. 2005, 2007). This encouraged us to continue to gather as many accurate observations as possible.

The mutual events of the Galilean satellites have been extensively observed since 1973 (Arlot 1973) but have recently benefitted from improvements in detectors which have made the observations easier. Having observations over long periods of time increases the possibility of obtaining results on the evolution of the orbits.

We choose to perform an observational campaign for the next Jovian equinox, allowing mutual events to occur. For that, we use the best theoretical dynamical model of motion of the Galilean satellites to predict these events.

## 2. The mutual events

### 2.1. Occurrence of the events

Since the Galilean satellites have their orbits almost in the same plane, mutual events occur regularly when the Earth (for the occultations) and the Sun (for the eclipses) pass through the orbital plane of the satellites. These planes corresponds closely to the equatorial plane of Jupiter. This occurrence takes place at the equinox on Jupiter, i.e. when the jovicentric declination of the Sun (and the Earth, which appears to be close to the Sun as seen from Jupiter) are near zero. Figure 1 shows the variation of these jovicentric declinations for the equinoxes of 2003 and 2009: the best periods for large, deep, mutual events appear to be May 2009 for the occultations and July 2009 for the eclipses. Fortunately, the opposition of Jupiter with the Sun occurs in August 2009, allowing observations from May to November 2009.

### 2.2. Nature of the events

Descriptions of the mutual eclipses and occultations have been made in previous papers, especially in technical notes made for the former occurrences (2003, 1997, etc.) available on the web site of IMCCE at the address http://www.imcce.fr/phemu09 or in Arlot (1999). Two types of events will occur:

- occultations consist of the arrival of the disk of the occulting satellite on that of the occulted satellite. Therefore, the amount of light received by a terrestrial observer decreases and increases during the event;
- eclipses correspond to the arrival of the eclipsed satellite in the shadow cone of the eclipsing satellite. In this case, only the eclipsed satellite may be observed, leading, in some cases, to a total eclipse (the complete disappearance of the eclipsed satellite).

During the occurrence of the mutual events, the magnitude of the events will be small at the beginning and the end of the period (the jovicentric declinations of the Earth and the Sun is not yet zero and the satellites are not exactly on the same line as seen from the Earth (or the Sun). On the other hand, the magnitude of the events will be larger for the zero value of the jovicentric declination of the Earth and the Sun. Observers should be aware that the signal to noise ratio will be larger for deep phenomena.

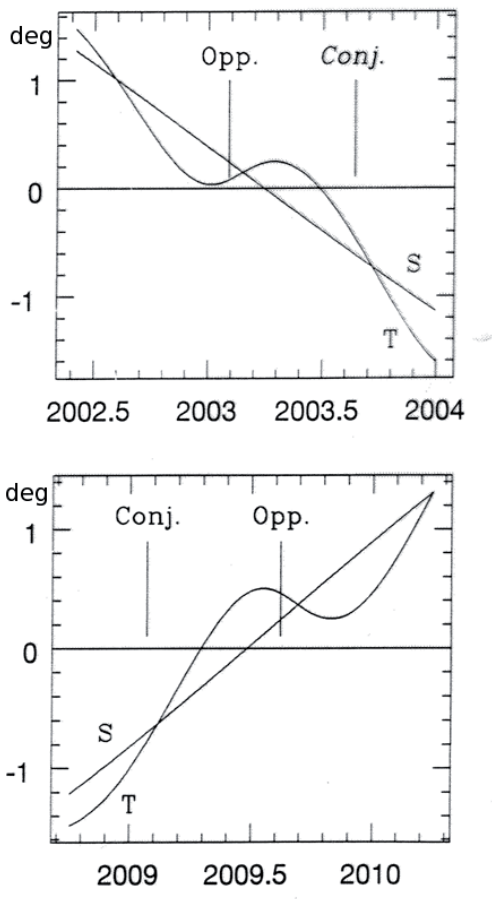


**Fig. 1.** Jovicentric declination of the Earth (T) and the Sun (S).

## 3. The predictions for 2009–2010

### *3.1. The model used for the predictions*

The prediction of the events requires the use of an accurate model of the motion of the Galilean satellites since the occurrence of the events is very sensitive to the small inclinations of the orbits of the Galilean satellites to the equatorial plane of Jupiter. A difference of a few tenths of an arcsecond in the relative positions of the Galilean satellites may affect whether the event will occur or not. Therefore, we use the recent accurate ephemerides L1 proposed by Lainey et al. (2006). We also provide data calculated using the G5 ephemerides (Arlot 1982) which was used for the former predictions. All these ephemerides are available on the Web site of IMCCE at `http://www.imcce.fr/sat`.

The calculations for the prediction of the events differ for the occultations and for the eclipses. For the occultations, we determinate the time of the first contact, maximum and last contact of the two disks of the satellites as seen from the Earth. For the eclipses, we may not consider that they are occultations as seen from the Sun because of the light-time. Therefore, we calculate the first and last contact of the eclipsed satellite with the penumbral and umbral cones and the minimum distance to the axis of the cones. The relative positions of the cones and the satellites are calculated carefully taking into account the light-time. In some cases, the relative velocity of the two satellites or of the eclipsed satellite with reference to the cones is very small, or has non linear variations. Some events have two minimums and this induces some errors in the times of the beginning and end of these events and will make the reduction of the observation more difficult.

What are the accuracies of these predictions? Since we used two different dynamical models fitted on different sets of observations, the differences in the predictions are a good estimate of the accuracy of the predictions. In Tables 2 to 10, the difference between Cols. 6 and 7 provides the accuracy for the date of the maximum of the event, the difference between Cols. 12 and 13 provides the accuracy in magnitude drop and the difference between Cols. 14 and 15 the accuracy on the duration of the event. Note that the prediction using L1 ephemerides would be nearer the real value.

### *3.2. The data*

The predicted mutual events are available with this paper on the web site of the IMCCE at the address: `http://www.imcce.fr/phemu09`. Tables 2 to 10 provide the detailed data calculated with the L1 ephemeris except for some data provided also calculated with the G5 ephemerides (as indicated below).

Column 1: date of the maximum of the event.
Column 2: nature of the event: 1 OCC 2 means that satellite 1 occults satellite 2, 3 ECL 4 means that satellite 3 eclipses satellite 4, etc.; P stands for partial, A for annular, T for total and blank means eclipse by the penumbra.
Column 3: (only for eclipses): hour, min, s in UTC of the beginning of the eclipse by the penumbra.
Column 4: hour, min, sec in TT of the beginning of the eclipse by the shadow or beginning of the occultation.
Column 5: (only for total events) hour, min, s in UTC of the beginning of totality.
Column 6: hour, min, s in TT of the maximum of the event.
Column 7: hour, min, s in TT of the maximum of the event calculated with G5 ephemeris.
Column 8: (only for total events) hour, min, s in UTC of the end of totality.
Column 9: hour, min, s in TT of the end of the eclipse by the shadow or end of the occultation.
Column 10: (only for eclipses): hour, min, s in TT of the end of the eclipse by the penumbra.
Column 11: flux drop in the $V$-band (if 0, grazing event with an eventual very small signal to be detected; if 1, total event).
Column 12: flux drop with the same albedoes for all the implied satellites (if 0, grazing event with an eventual very small signal to be detected; if 1, total event).
Column 13: flux drop with the same albedoes for all the implied satellites (if 0, grazing event with an eventual very small signal to be detected; if 1, total event) calculated with G5 ephemeris.
Column 14: duration of the event in seconds; no duration is indicated for grazing events. The eclipse inside the penumbra is not taken into account in the duration.
Column 15: duration of the event in seconds calculated with G5 ephemeris; no duration is indicated for grazing events. The eclipse inside the penumbra is not taken into account in the duration.
Column 16: apparent distance from the occulted or eclipsed satellite to the center of Jupiter in jovian radii. When this distance is less than 1, this means that the event occurs in front of the planet Jupiter. This

is a nice observation – especially the eclipses – with a good seeing, but without any scientific interest!

Column 17: impact parameter in arcsec (distance between the centers of the satellites for the occultations and from the eclipsed satellite to the axis of the shadow cone for the eclipses).

The dates are provided in Terrestrial Time (TT) since the UTC for this period is not yet available. The difference TT – UTC will, however, be near 67 s in 2009. Note that observations will be recorded in reference to UTC.

In the list of events in Tables 2 to 10, two events present two minima in the predicted light curves, because of the length of these events and of the changing velocity of the satellites during the events:

- on September 6, 2009, J1 occults J3 with a first minimum distance at 10 h 28 min and a second one at 10 h 30 min (event from 10 h to 13 h);
- on September 8, 2009, J1 occults J2 with a first minimum distance at 6 h 5 min and a second one at 7 h 30 min (event from 5 h 30 min to 8 h).

Some events will occur during an eclipse by Jupiter: we removed these events from the list but we leave the following events during which an eclipse occurs or for which the eclipse occurs just before or just after the mutual event:

- on January 20, 2009, the eclipse of J3 by J2 ends at 12h16min TT and the eclipse of J3 starts at 12h31min TT
- on May 26, 2009, the eclipse of J4 by J2 starts at 8h30min TT and the eclipse of J4 ends at 8h19min TT
- on June 3, 2009, J4 eclipses J1 from 3h27min to 3h36min TT and the eclipse of J1 starts at 3h31min TT
- on June 17, 2009, J2 occults J1 from 7h16min to 7h19min TT and the eclipse of J1 starts at 7h18min TT
- on July 15, 2009, the eclipse of J4 by J3 starts at 2h20min TT and the eclipse of J4 ends at 2h9min TT
- on July 22, 2009, the eclipse of J1 by J2 ends at 16h37min TT and the eclipse of J1 starts at 16h47min TT
- on July 26, 2009, the eclipse of J1 by J2 ends at 5h43min TT and the eclipse of J1 starts at 5h44min TT
- on August 12, 2009, the eclipse of J1 by J3 ends at 22h28min TT and the eclipse of J1 starts at 22h29min TT
- on August 30, 2009, the occultation of J3 by J1 ends at 14h48min TT and J3 is occulted by Jupiter starting at 15h0min TT
- on September 20, 2009, the eclipse of J1 by J2 starts at 23h19min TT and the eclipse of J1 ends at 23h18min TT
- on November 5, 2009, the occultation of J1 by J2 starts at 23h51min TT and the eclipse of J1 ends at 23h47min TT
- on November 9, 2009, the occultation of J1 by J2 starts at 12h58min TT and the eclipse of J1 ends at 12h44min TT

The magnitude drops are provided under several forms: first the flux drop in magnitude units more understandable for human eyes (0 = no decrease of light, unchanged magnitude of the object(s); n = increase in magnitude at the maximum of the event) and second in unit of flux (0 = no decrease of light; 1 = total disappearance of the object). We calculated the drop depending on the albedoes of the implied satellites (for the occultations) in the $V$-band which is commonly used by the observers. Table 1 provides the values used for the albedoes. They are taken from Morrisson and Morrison (1977) for a phase not equal to zero. Note that they have very little influence on the results (they do not influence at all the magnitude drop of the eclipses) and are not very different in the other bands. We also provide the flux drop without albedoes i.e. with the same albedoes for the four satellites.

**Table 1.** Albedoes used for the calculation of the magnitude drop.

| | satellites | $V$-band |
|---|---|---|
| J-1 | Io | 0.56 |
| J-2 | Europa | 0.62 |
| J-3 | Ganymede | 0.39 |
| J-4 | Callisto | 0.14 |

During the 2009–2010 event season, 443 events were predicted. Not all of them are observable: some will remain grazing with no detectable signal, some will occur behind Jupiter or during an eclipse by the planet and some will be difficult to observe because of the conjunction of Jupiter with the Sun. Only 370 are presented here. In the next sections, we provide more information on the visibility and on the observability of these events.

### 3.3. The visibility of the events

Since they occur anytime and since their duration is, usually, only a few minutes, the events are observable only from selected sites where Jupiter is visible, above the horizon at the time of the event. The declination of Jupiter during the occurrence of the mutual events will be near −14 degrees. Therefore, the observations will be easier in the southern hemisphere. Table 11 provides the number of events observable from some selected sites around the world (calculated from 440 events including some grazing not in Tables 2 to 10 but provided on our web server). We considered that an event is observable when the Sun is more than 10 degrees under the horizon and Jupiter is more than 15 degrees above the horizon. Table 12 provides the number of events depending on several criteria. Note that some events may be observable or not because of the sensitivity of these events to the inclinations of the orbital planes of the satellites. We considered that these events are possibly grazing i.e. its observability depends on the possible error in the ephemerides. So, if a signal is detected during an event, one will get valuable information about the ephemerides. Note also that the total or annular events will present light curves with a flat step allowing the analysis of the scattering law of the light on the surfaces of the satellites. Short events or faint events (the flux drop of which being less than ten percent) will be difficult to catch because of the low signal to noise ratio, and observers will need near perfect photometric conditions. The long events (one hour or more) are interesting too, but observers must take into account the changing elevation of Jupiter on the sky: the event must end before Jupiter sets. The observers should be aware that the predicted times may have an error of a few minutes in some cases, even if they are within a few seconds most of the time. This difference between the observation and the prediction contains information relevant to improving the theoretical models of the motions of the satellites. Therefore, the observations should start at least 10 min before the predicted beginning and must be referred to UTC within less than one tenth of a second.

Information on the visibility of the events from any site of observation is provided on the web site of IMCCE at the address `http://www.imcce.fr/phemu09`.

**Table 2.** Mutual events occurring from January 13 to May 12, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 1 13 | 2 ECL 3 P | 14 25 26. | 14 32 24. | | 14 45 25. | 14 47 46. | | 14 58 34. | 15 5 54. | 0.080 | 0.080 | 0.070 | 1570 | 1462 | 0.2 | 0.856 |
| 2009 1 13 | 2 OCC 3 P | | 15 54 50. | | 16 2 17. | 16 3 10. | | 16 9 45. | | 0.002 | 0.003 | 0.001 | 895 | 497 | 0.3 | 0.922 |
| 2009 1 20 | 2 ECL 3 | 11 51 2. | | | 12 3 32. | 12 5 45. | | | 12 15 38. | 0.016 | 0.016 | 0.010 | | | 0.3 | 1.082 |
| 2009 3 27 | 4 OCC 3 P | | 5 42 56. | | 5 45 55. | 5 47 41. | | 5 48 55. | | 0.021 | 0.032 | 0.037 | 359 | 376 | 8.3 | 1.048 |
| 2009 3 28 | 4 OCC 1 P | | 3 6 58. | | 3 8 53. | 3 8 18. | | 3 10 48. | | 0.056 | 0.058 | 0.062 | 230 | 234 | 5.8 | 0.800 |
| 2009 4 4 | 2 ECL 4 | 15 12 11. | | | 16 23 29. | 16 22 23. | | | 17 20 20. | 0.044 | 0.044 | 0.034 | | | 6.7 | 1.111 |
| 2009 4 5 | 1 OCC 4 P | | 7 22 30. | | 7 27 50. | 7 30 54. | | 7 33 16. | | 0.085 | 0.363 | 0.362 | 645 | 651 | 11.3 | 0.147 |
| 2009 4 6 | 1 OCC 4 P | | 10 1 48. | | 10 5 52. | 10 4 37. | | 10 9 54. | | 0.066 | 0.281 | 0.292 | 487 | 493 | 10.3 | 0.340 |
| 2009 4 9 | 1 OCC 3 P | | 23 57 48. | | 23 59 52. | 23 58 56. | | 0 1 55. | | 0.028 | 0.042 | 0.045 | 247 | 252 | 9.4 | 0.912 |
| 2009 4 13 | 3 OCC 1 P | | 0 54 14. | | 0 55 56. | 0 55 30. | | 0 57 38. | | 0.049 | 0.051 | 0.049 | 204 | 201 | 4.8 | 0.892 |
| 2009 4 13 | 4 OCC 2 P | | 6 25 57. | | 6 32 49. | 6 30 15. | | 6 39 46. | | 0.217 | 0.203 | 0.203 | 830 | 825 | 15.0 | 0.448 |
| 2009 4 13 | 4 ECL 1 | 17 23 60. | | | 17 29 9. | 17 28 38. | | | 17 34 21. | 0.038 | 0.038 | 0.039 | | | 3.0 | 1.295 |
| 2009 4 14 | 4 OCC 1 P | | 13 6 29. | | 13 9 17. | 13 10 19. | | 13 12 5. | | 0.232 | 0.241 | 0.232 | 336 | 332 | 5.6 | 0.425 |
| 2009 4 15 | 4 OCC 2 P | | 4 51 58. | | 4 58 13. | 4 55 58. | | 5 4 24. | | 0.314 | 0.293 | 0.284 | 746 | 743 | 3.4 | 0.231 |
| 2009 4 15 | 4 OCC 3 P | | 14 57 41. | | 15 3 31. | 15 4 30. | | 15 9 20. | | 0.137 | 0.208 | 0.208 | 700 | 704 | 14.0 | 0.609 |
| 2009 4 17 | 1 OCC 3 P | | 3 0 27. | | 3 3 15. | 3 2 29. | | 3 6 3. | | 0.118 | 0.182 | 0.185 | 336 | 338 | 8.1 | 0.567 |
| 2009 4 20 | 3 OCC 1 P | | 3 47 5. | | 3 49 43. | 3 49 8. | | 3 52 21. | | 0.205 | 0.212 | 0.209 | 317 | 315 | 6.3 | 0.503 |
| 2009 4 21 | 2 OCC 4 P | | 21 27 56. | | 21 31 41. | 21 30 47. | | 21 35 26. | | 0.038 | 0.166 | 0.160 | 450 | 444 | 5.3 | 0.537 |
| 2009 4 22 | 1 OCC 2 P | | 20 22 55. | | 20 23 27. | 20 24 10. | | 20 23 59. | | 0.003 | 0.003 | 0.006 | 64 | 81 | 7.5 | 0.848 |
| 2009 4 24 | 1 OCC 3 A | | 5 56 52. | | 5 59 50. | 5 59 12. | | 6 2 47. | | 0.209 | 0.322 | 0.322 | 355 | 356 | 6.8 | 0.189 |
| 2009 4 24 | 2 OCC 3 P | | 11 22 20. | | 11 24 21. | 11 24 19. | | 11 26 22. | | 0.027 | 0.042 | 0.049 | 242 | 253 | 5.1 | 0.888 |
| 2009 4 26 | 1 OCC 2 P | | 9 31 12. | | 9 32 27. | 9 33 11. | | 9 33 42. | | 0.045 | 0.043 | 0.049 | 150 | 157 | 7.8 | 0.727 |
| 2009 4 27 | 3 OCC 1 T | | 6 41 34. | 6 44 13. | 6 44 40. | 6 43 57. | 6 45 7. | 6 47 47. | | 0.310 | 0.321 | 0.321 | 374 | 372 | 7.6 | 0.009 |
| 2009 4 29 | 1 OCC 2 P | | 22 39 43. | | 22 41 21. | 22 42 6. | | 22 42 59. | | 0.106 | 0.100 | 0.108 | 196 | 201 | 8.0 | 0.611 |
| 2009 4 30 | 4 OCC 2 P | | 12 38 44. | | 12 39 57. | 12 41 3. | | 12 41 11. | | 0.010 | 0.010 | 0.005 | 148 | 120 | 3.2 | 0.981 |
| 2009 5 1 | 1 OCC 3 A | | 8 48 43. | | 8 51 31. | 8 51 2. | | 8 54 19. | | 0.209 | 0.322 | 0.322 | 336 | 336 | 5.4 | 0.211 |
| 2009 5 1 | 2 OCC 3 P | | 14 44 38. | | 14 47 32. | 14 47 47. | | 14 50 27. | | 0.110 | 0.170 | 0.178 | 349 | 354 | 3.5 | 0.557 |
| 2009 5 2 | 2 OCC 1 P | | 5 6 24. | | 5 7 18. | 5 7 36. | | 5 8 13. | | 0.017 | 0.018 | 0.024 | 109 | 119 | 7.0 | 0.810 |
| 2009 5 3 | 1 OCC 2 P | | 11 48 5. | | 11 49 59. | 11 50 45. | | 11 51 53. | | 0.175 | 0.166 | 0.175 | 228 | 231 | 8.2 | 0.498 |
| 2009 5 4 | 3 OCC 2 P | | 4 59 5. | | 5 0 57. | 5 0 42. | | 5 2 50. | | 0.030 | 0.028 | 0.027 | 225 | 222 | 7.7 | 0.963 |
| 2009 5 4 | 3 OCC 1 T | | 9 37 53. | 9 40 56. | 9 41 15. | 9 40 21. | 9 41 33. | 9 44 37. | | 0.310 | 0.321 | 0.321 | 404 | 404 | 8.8 | 0.009 |
| 2009 5 5 | 2 OCC 1 P | | 18 13 51. | | 18 15 13. | 18 15 32. | | 18 16 36. | | 0.066 | 0.070 | 0.079 | 165 | 171 | 6.8 | 0.683 |
| 2009 5 7 | 1 OCC 2 P | | 0 56 23. | | 0 58 28. | 0 59 17. | | 1 0 34. | | 0.248 | 0.234 | 0.244 | 252 | 254 | 8.5 | 0.388 |
| 2009 5 8 | 1 OCC 3 P | | 11 37 3. | | 11 39 23. | 11 39 1. | | 11 41 44. | | 0.113 | 0.174 | 0.173 | 282 | 282 | 4.0 | 0.622 |
| 2009 5 8 | 1 ECL 4 | 16 7 16. | | | 16 10 31. | 16 10 56. | | | 16 13 46. | 0.104 | 0.104 | 0.107 | | | 9.8 | 1.167 |
| 2009 5 8 | 2 OCC 3 A | | 18 4 17. | | 18 7 30. | 18 7 59. | | 18 10 43. | | 0.168 | 0.261 | 0.261 | 386 | 388 | 2.1 | 0.210 |
| 2009 5 9 | 2 OCC 1 P | | 7 21 8. | | 7 22 46. | 7 23 4. | | 7 24 25. | | 0.131 | 0.139 | 0.149 | 198 | 201 | 6.5 | 0.554 |
| 2009 5 10 | 1 OCC 2 P | | 14 4 26. | | 14 6 41. | 14 7 31. | | 14 8 55. | | 0.320 | 0.302 | 0.312 | 269 | 271 | 8.7 | 0.283 |
| 2009 5 11 | 3 OCC 2 P | | 8 20 55. | | 8 24 11. | 8 23 38. | | 8 27 27. | | 0.181 | 0.168 | 0.166 | 393 | 390 | 9.3 | 0.576 |
| 2009 5 11 | 3 OCC 1 P | | 12 37 55. | | 12 41 26. | 12 40 21. | | 12 44 58. | | 0.228 | 0.236 | 0.240 | 423 | 424 | 10.0 | 0.476 |
| 2009 5 12 | 2 OCC 1 P | | 20 28 5. | | 20 29 54. | 20 30 11. | | 20 31 43. | | 0.204 | 0.216 | 0.228 | 218 | 220 | 6.3 | 0.425 |

**Table 3.** Mutual events occurring from May 14 to June 6, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 5 14 | 1 OCC 2 P | | 3 12 26. | | 3 14 47. | 3 15 38. | | 3 17 9. | | 0.389 | 0.367 | 0.376 | 283 | 284 | 8.9 | 0.183 |
| 2009 5 15 | 1 OCC 3 P | | 14 22 37. | | 14 24 5. | 14 23 50. | | 14 25 33. | | 0.024 | 0.037 | 0.036 | 176 | 176 | 2.6 | 1.032 |
| 2009 5 15 | 2 OCC 3 A | | 21 20 60. | | 21 24 10. | 21 24 52. | | 21 27 21. | | 0.168 | 0.261 | 0.261 | 381 | 381 | 0.8 | 0.148 |
| 2009 5 16 | 4 ECL 3 | 4 5 28. | | | 4 11 59. | 4 12 7. | | | 4 18 29. | 0.206 | 0.206 | 0.211 | | | 2.6 | 1.174 |
| 2009 5 16 | 2 OCC 1 P | | 9 34 40. | | 9 36 35. | 9 36 53. | | 9 38 30. | | 0.281 | 0.298 | 0.310 | 230 | 232 | 6.0 | 0.295 |
| 2009 5 16 | 4 ECL 1 P | 18 39 21. | 18 43 52. | | 18 44 54. | 18 45 23. | | 18 45 56. | 18 50 31. | 0.482 | 0.482 | 0.483 | 124 | 127 | 8.5 | 0.559 |
| 2009 5 17 | 4 ECL 1 P | 10 46 6. | 10 51 42. | | 10 56 36. | 10 56 8. | | 11 1 31. | 11 7 16. | 0.572 | 0.572 | 0.575 | 589 | 593 | 0.9 | 0.377 |
| 2009 5 17 | 1 OCC 2 P | | 16 20 7. | | 16 22 33. | 16 23 26. | | 16 24 60. | | 0.446 | 0.421 | 0.425 | 292 | 293 | 9.1 | 0.087 |
| 2009 5 17 | 4 ECL 1 | 21 4 26. | | | 21 11 27. | 21 12 3. | | | 21 18 21. | 0.285 | 0.285 | 0.298 | | | 11.8 | 0.956 |
| 2009 5 18 | 3 OCC 2 T | | 11 41 21. | 11 44 30. | 11 45 13. | 11 44 24. | 11 45 56. | 11 49 5. | | 0.279 | 0.259 | 0.259 | 464 | 462 | 10.7 | 0.009 |
| 2009 5 18 | 3 OCC 1 P | | 15 43 30. | | 15 47 13. | 15 45 53. | | 15 50 57. | | 0.146 | 0.151 | 0.156 | 447 | 449 | 10.9 | 0.700 |
| 2009 5 19 | 2 OCC 1 P | | 22 40 54. | | 22 42 52. | 22 43 9. | | 22 44 50. | | 0.357 | 0.379 | 0.391 | 237 | 237 | 5.8 | 0.166 |
| 2009 5 21 | 1 OCC 2 T | | 5 27 45. | 5 30 3. | 5 30 14. | 5 31 9. | 5 30 26. | 5 32 44. | | 0.450 | 0.425 | 0.425 | 300 | 300 | 9.3 | 0.006 |
| 2009 5 23 | 2 OCC 3 P | | 0 34 57. | | 0 37 47. | 0 38 39. | | 0 40 37. | | 0.130 | 0.201 | 0.193 | 340 | 337 | 0.3 | 0.511 |
| 2009 5 23 | 2 OCC 1 A | | 11 46 43. | | 11 48 42. | 11 48 59. | | 11 50 41. | | 0.402 | 0.426 | 0.426 | 238 | 238 | 5.5 | 0.038 |
| 2009 5 24 | 1 OCC 2 P | | 18 34 59. | | 18 37 31. | 18 38 27. | | 18 40 3. | | 0.445 | 0.420 | 0.414 | 304 | 304 | 9.5 | 0.090 |
| 2009 5 25 | 3 OCC 2 T | | 15 0 11. | 15 3 17. | 15 4 15. | 15 3 10. | 15 5 13. | 15 8 20. | | 0.279 | 0.259 | 0.259 | 489 | 488 | 12.0 | 0.009 |
| 2009 5 25 | 3 OCC 1 P | | 19 0 22. | | 19 4 38. | 19 2 54. | | 19 8 58. | | 0.100 | 0.104 | 0.108 | 515 | 518 | 11.6 | 0.848 |
| 2009 5 25 | 3 ECL 4 | 21 20 51. | | | 21 24 11. | 21 24 26. | | | 21 27 30. | 0.031 | 0.031 | 0.031 | | | 2.2 | 1.825 |
| 2009 5 26 | 1 ECL 4 | 1 19 36. | | | 1 23 51. | 1 24 17. | | | 1 28 6. | 0.343 | 0.343 | 0.349 | | | 2.3 | 0.652 |
| 2009 5 26 | 3 OCC 1 P | | 8 2 42. | | 8 14 34. | 8 15 1. | | 8 26 40. | | 0.300 | 0.311 | 0.311 | 1438 | 1431 | 2.9 | 0.291 |
| 2009 5 26 | 2 ECL 4 | 8 30 33. | | | 8 32 5. | 8 32 22. | | | 8 33 37. | 0.003 | 0.003 | 0.005 | | | 0.5 | 1.588 |
| 2009 5 26 | 3 OCC 1 P | | 16 53 20. | | 16 59 8. | 17 0 57. | | 17 4 46. | | 0.072 | 0.075 | 0.070 | 686 | 669 | 11.8 | 0.939 |
| 2009 5 27 | 2 OCC 1 P | | 0 52 11. | | 0 54 8. | 0 54 25. | | 0 56 6. | | 0.397 | 0.422 | 0.413 | 235 | 234 | 5.3 | 0.088 |
| 2009 5 28 | 1 OCC 2 P | | 7 42 12. | | 7 44 45. | 7 45 44. | | 7 47 19. | | 0.402 | 0.379 | 0.371 | 307 | 307 | 9.6 | 0.170 |
| 2009 5 29 | 1 ECL 3 | 16 51 30. | | | 16 51 58. | 16 51 50. | | | 16 52 25. | 0.000 | 0.000 | 0.000 | | | 0.8 | 1.563 |
| 2009 5 30 | 2 OCC 3 P | | 3 45 30. | | 3 47 39. | 3 48 39. | | 3 49 49. | | 0.051 | 0.079 | 0.071 | 259 | 252 | 1.2 | 0.870 |
| 2009 5 30 | 2 OCC 1 P | | 13 57 12. | | 13 59 7. | 13 59 23. | | 14 1 1. | | 0.335 | 0.356 | 0.344 | 229 | 227 | 5.1 | 0.213 |
| 2009 5 31 | 1 OCC 2 P | | 20 48 59. | | 20 51 33. | 20 52 33. | | 20 54 8. | | 0.357 | 0.337 | 0.329 | 309 | 308 | 9.8 | 0.245 |
| 2009 6 1 | 3 ECL 1 | 18 10 25. | | | 18 12 58. | 18 12 54. | | | 18 15 33. | 0.028 | 0.028 | 0.023 | | | 9.8 | 1.321 |
| 2009 6 1 | 3 OCC 2 P | | 18 17 8. | | 18 21 9. | 18 19 50. | | 18 25 10. | | 0.254 | 0.236 | 0.239 | 481 | 482 | 13.0 | 0.421 |
| 2009 6 1 | 3 OCC 1 P | | 22 44 58. | | 22 51 42. | 22 49 4. | | 22 58 41. | | 0.095 | 0.099 | 0.102 | 824 | 823 | 11.6 | 0.884 |
| 2009 6 2 | 4 ECL 2 P | 1 40 12. | 1 50 20. | | 1 57 28. | 1 59 5. | | 2 4 53. | 2 15 38. | 0.563 | 0.563 | 0.564 | 873 | 886 | 14.3 | 0.291 |
| 2009 6 2 | 3 OCC 1 P | | 6 25 14. | | 6 37 47. | 6 39 25. | | 6 50 1. | | 0.268 | 0.278 | 0.281 | 1486 | 1477 | 3.1 | 0.400 |
| 2009 6 3 | 2 OCC 1 P | | 3 1 50. | | 3 3 40. | 3 3 56. | | 3 5 29. | | 0.269 | 0.285 | 0.274 | 219 | 217 | 4.9 | 0.334 |
| 2009 6 3 | 4 ECL 1 A | 3 27 36. | 3 30 26. | | 3 31 46. | 3 32 9. | | 3 33 5. | 3 35 55. | 0.425 | 0.425 | 0.423 | 159 | 160 | 4.1 | 0.180 |
| 2009 6 3 | 4 ECL 2 P | 22 37 34. | 22 43 28. | | 22 44 57. | 22 45 39. | | 22 46 21. | 22 52 15. | 0.500 | 0.500 | 0.503 | 173 | 193 | 5.6 | 0.494 |
| 2009 6 4 | 1 OCC 2 P | | 9 55 46. | | 9 58 21. | 9 59 23. | | 10 0 56. | | 0.316 | 0.299 | 0.291 | 310 | 309 | 10.0 | 0.313 |
| 2009 6 4 | 4 ECL 3 | 11 34 23. | | | 11 41 49. | 11 41 58. | | | 11 49 15. | 0.140 | 0.140 | 0.138 | | | 20.0 | 1.252 |
| 2009 6 6 | 2 OCC 3 P | | 6 53 28. | | 6 54 9. | 6 55 13. | | 6 54 50. | | 0.001 | 0.002 | 0.000 | 82 | 44 | 1.9 | 1.215 |
| 2009 6 6 | 2 OCC 1 P | | 16 6 3. | | 16 7 46. | 16 8 2. | | 16 9 29. | | 0.208 | 0.220 | 0.209 | 206 | 203 | 4.6 | 0.452 |

**Table 4.** Mutual events occurring from June 7 to July 4, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 6 7 | 1 OCC 2 P | | 23 2 5. | | 23 4 40. | 23 5 43. | | 23 7 15. | | 0.281 | 0.265 | 0.257 | 310 | 308 | 10.1 | 0.375 |
| 2009 6 8 | 3 ECL 1 | 21 28 6. | | | 21 32 41. | 21 32 31. | | | 21 37 19. | 0.122 | 0.122 | 0.109 | | | 11.0 | 1.106 |
| 2009 6 8 | 3 OCC 2 P | | 21 32 21. | | 21 36 6. | 21 34 36. | | 21 39 51. | | 0.161 | 0.150 | 0.155 | 450 | 453 | 13.8 | 0.685 |
| 2009 6 9 | 3 ECL 1 P | 10 23 37. | 10 29 19. | | 10 33 12. | 10 34 17. | | 10 37 6. | 10 42 57. | 0.150 | 0.150 | 0.144 | 467 | 445 | 0.1 | 0.973 |
| 2009 6 9 | 3 ECL 1 P | 19 25 58. | 19 31 45. | | 19 33 26. | 19 33 6. | | 19 34 45. | 19 40 38. | 0.190 | 0.190 | 0.193 | 180 | 178 | 11.5 | 0.952 |
| 2009 6 10 | 2 OCC 1 P | | 5 9 52. | | 5 11 27. | 5 11 43. | | 5 13 2. | | 0.153 | 0.163 | 0.152 | 190 | 187 | 4.4 | 0.566 |
| 2009 6 10 | 3 ECL 4 A | 7 22 25. | 7 27 31. | | 7 30 34. | 7 30 51. | | 7 33 37. | 7 38 44. | 0.476 | 0.476 | 0.473 | 366 | 364 | 15.6 | 0.263 |
| 2009 6 10 | 2 ECL 4 | 14 32 20. | | | 14 39 17. | 14 39 40. | | | 14 46 17. | 0.444 | 0.444 | 0.448 | | | 7.9 | 0.352 |
| 2009 6 11 | 1 ECL 4 | 6 9 44. | | | 6 13 56. | 6 14 23. | | | 6 18 8. | 0.455 | 0.455 | 0.450 | | | 8.0 | 0.384 |
| 2009 6 11 | 1 OCC 2 P | | 12 8 26. | | 12 11 0. | 12 12 6. | | 12 13 36. | | 0.251 | 0.237 | 0.230 | 310 | 309 | 10.3 | 0.430 |
| 2009 6 13 | 2 OCC 1 P | | 18 13 16. | | 18 14 41. | 18 14 57. | | 18 16 7. | | 0.106 | 0.113 | 0.104 | 172 | 168 | 4.2 | 0.675 |
| 2009 6 14 | 1 ECL 2 | 23 21 43. | | | 23 22 18. | 23 22 39. | | | 23 22 55. | 0.001 | 0.001 | 0.002 | | | 10.5 | 1.099 |
| 2009 6 15 | 1 OCC 2 P | | 1 14 16. | | 1 16 51. | 1 17 58. | | 1 19 26. | | 0.226 | 0.213 | 0.206 | 311 | 309 | 10.5 | 0.478 |
| 2009 6 16 | 3 OCC 2 P | | 0 46 8. | | 0 49 28. | 0 47 50. | | 0 52 48. | | 0.088 | 0.082 | 0.087 | 400 | 407 | 14.3 | 0.908 |
| 2009 6 16 | 3 ECL 1 P | 1 21 57. | 1 27 47. | | 1 30 49. | 1 30 23. | | 1 33 36. | 1 40 6. | 0.208 | 0.208 | 0.194 | 349 | 293 | 11.7 | 0.920 |
| 2009 6 16 | 3 ECL 1 P | 8 35 6. | 8 40 56. | | 8 46 54. | 8 48 3. | | 8 52 60. | 8 58 21. | 0.215 | 0.215 | 0.203 | 724 | 692 | 5.9 | 0.895 |
| 2009 6 16 | 3 ECL 1 P | 23 12 5. | 23 15 29. | | 23 17 36. | 23 17 27. | | 23 19 40. | 23 23 1. | 0.307 | 0.307 | 0.312 | 251 | 256 | 11.8 | 0.812 |
| 2009 6 17 | 2 OCC 1 P | | 7 16 16. | | 7 17 31. | 7 17 46. | | 7 18 46. | | 0.068 | 0.072 | 0.064 | 150 | 145 | 4.0 | 0.778 |
| 2009 6 18 | 1 ECL 2 | 12 29 50. | | | 12 31 5. | 12 31 26. | | | 12 32 18. | 0.009 | 0.009 | 0.012 | | | 10.7 | 1.032 |
| 2009 6 18 | 1 OCC 2 P | | 14 20 11. | | 14 22 46. | 14 23 56. | | 14 25 23. | | 0.206 | 0.195 | 0.188 | 312 | 310 | 10.6 | 0.519 |
| 2009 6 19 | 4 ECL 2 | 5 7 25. | | | 5 12 36. | 5 13 12. | | | 5 17 48. | 0.525 | 0.525 | 0.521 | | 25 | 5.3 | 0.504 |
| 2009 6 19 | 4 ECL 1 | 8 29 28. | | | 8 33 51. | 8 34 18. | | | 8 38 16. | 0.354 | 0.354 | 0.348 | | | 7.2 | 0.904 |
| 2009 6 19 | 4 ECL 3 | 23 16 4. | | | 23 22 51. | 23 22 49. | | | 23 29 38. | 0.545 | 0.545 | 0.545 | | | 2.6 | 0.219 |
| 2009 6 20 | 4 ECL 1 P | 4 53 9. | 5 4 21. | | 5 11 29. | 5 10 37. | | 5 18 54. | 5 32 21. | 0.491 | 0.491 | 0.483 | 873 | 842 | 6.5 | 0.535 |
| 2009 6 20 | 4 ECL 1 P | 9 18 3. | 9 30 57. | | 9 37 58. | 9 39 7. | | 9 44 28. | 9 55 9. | 0.524 | 0.524 | 0.519 | 811 | 785 | 11.1 | 0.424 |
| 2009 6 22 | 1 ECL 2 | 1 38 13. | | | 1 39 52. | 1 40 14. | | | 1 41 34. | 0.026 | 0.026 | 0.031 | | | 10.9 | 0.966 |
| 2009 6 22 | 1 OCC 2 P | | 3 25 34. | | 3 28 11. | 3 29 22. | | 3 30 49. | | 0.191 | 0.180 | 0.174 | 315 | 312 | 10.7 | 0.553 |
| 2009 6 23 | 3 OCC 2 P | | 3 57 53. | | 4 0 41. | 3 59 0. | | 4 3 30. | | 0.041 | 0.039 | 0.043 | 336 | 349 | 14.5 | 1.085 |
| 2009 6 24 | 3 ECL 1 P | 2 28 25. | 2 30 56. | | 2 33 16. | 2 33 10. | | 2 35 37. | 2 38 4. | 0.466 | 0.466 | 0.471 | 281 | 283 | 11.4 | 0.643 |
| 2009 6 25 | 1 ECL 2 | 14 47 10. | | | 14 49 9. | 14 49 32. | | | 14 51 11. | 0.052 | 0.052 | 0.059 | | | 11.0 | 0.903 |
| 2009 6 25 | 1 OCC 2 P | | 16 31 4. | | 16 33 43. | 16 34 56. | | 16 36 23. | | 0.180 | 0.170 | 0.164 | 319 | 317 | 10.9 | 0.579 |
| 2009 6 27 | 1 ECL 3 P | 3 39 19. | 3 41 19. | | 3 42 30. | 3 42 21. | | 3 43 42. | 3 45 40. | 0.256 | 0.256 | 0.252 | 144 | 141 | 4.4 | 0.647 |
| 2009 6 27 | 2 ECL 4 | 22 12 54. | | | 22 17 44. | 22 18 2. | | | 22 22 35. | 0.519 | 0.519 | 0.525 | | | 8.7 | 0.245 |
| 2009 6 29 | 1 ECL 2 | 3 56 11. | | | 3 58 29. | 3 58 51. | | | 4 0 47. | 0.087 | 0.087 | 0.095 | | | 11.2 | 0.842 |
| 2009 6 29 | 1 OCC 2 P | | 5 36 2. | | 5 38 45. | 5 39 59. | | 5 41 28. | | 0.173 | 0.163 | 0.157 | 325 | 323 | 11.0 | 0.598 |
| 2009 6 29 | 3 ECL 4 A | 14 51 37. | 14 56 57. | | 15 1 5. | 15 1 31. | | 15 5 12. | 15 10 30. | 0.490 | 0.490 | 0.489 | 494 | 493 | 6.5 | 0.189 |
| 2009 6 30 | 3 OCC 2 P | | 7 8 23. | | 7 10 38. | 7 8 57. | | 7 12 52. | | 0.017 | 0.016 | 0.020 | 269 | 290 | 14.5 | 1.215 |
| 2009 7 1 | 3 ECL 1 P | 5 32 5. | 5 34 10. | | 5 36 34. | 5 36 30. | | 5 38 56. | 5 41 1. | 0.613 | 0.613 | 0.615 | 286 | 287 | 10.6 | 0.450 |
| 2009 7 2 | 1 ECL 2 | 17 5 51. | | | 17 8 24. | 17 8 48. | | | 17 10 59. | 0.122 | 0.122 | 0.127 | | | 11.3 | 0.785 |
| 2009 7 2 | 1 OCC 2 P | | 18 41 12. | | 18 43 59. | 18 45 16. | | 18 46 47. | | 0.170 | 0.161 | 0.155 | 334 | 332 | 11.1 | 0.609 |
| 2009 7 4 | 1 ECL 3 A | 6 22 54. | 6 24 40. | | 6 26 21. | 6 26 12. | | 6 28 1. | 6 29 48. | 0.337 | 0.337 | 0.332 | 201 | 199 | 5.6 | 0.421 |

**Table 5.** Mutual events occurring from July 5 to July 29, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 7 5 | 4 ECL 3 | 9 18 53. | | | 9 23 34. | 9 23 40. | | | 9 28 15. | 0.042 | 0.042 | 0.039 | | | 14.8 | 1.631 |
| 2009 7 6 | 1 ECL 2 P | 6 15 35. | 6 17 47. | | 6 18 24. | 6 18 47. | | 6 18 56. | 6 21 13. | 0.144 | 0.144 | 0.151 | 69 | 87 | 11.5 | 0.730 |
| 2009 7 6 | 1 OCC 2 P | | 7 45 52. | | 7 48 44. | 7 50 3. | | 7 51 38. | | 0.171 | 0.162 | 0.156 | 345 | 343 | 11.2 | 0.613 |
| 2009 7 6 | 4 ECL 1 | 17 36 56. | | | 17 39 17. | 17 39 42. | | | 17 41 39. | 0.054 | 0.054 | 0.049 | | | 4.9 | 1.437 |
| 2009 7 7 | 3 ECL 2 | 7 13 3. | | | 7 15 31. | 7 15 32. | | | 7 18 2. | 0.018 | 0.018 | 0.014 | | | 14.1 | 1.304 |
| 2009 7 7 | 3 OCC 2 P | | 10 16 56. | | 10 18 44. | 10 17 8. | | 10 20 32. | | 0.007 | 0.007 | 0.010 | 216 | 248 | 14.2 | 1.296 |
| 2009 7 8 | 3 ECL 1 P | 8 28 2. | 8 29 53. | | 8 32 14. | 8 32 12. | | 8 34 36. | 8 36 26. | 0.686 | 0.686 | 0.687 | 283 | 283 | 9.6 | 0.240 |
| 2009 7 8 | 2 ECL 1 | 12 10 19. | | | 12 11 0. | 12 11 6. | | | 12 11 42. | 0.004 | 0.004 | 0.005 | | | 4.8 | 1.131 |
| 2009 7 9 | 1 ECL 2 P | 19 26 4. | 19 27 55. | | 19 29 6. | 19 29 31. | | 19 30 11. | 19 32 10. | 0.180 | 0.180 | 0.190 | 136 | 146 | 11.6 | 0.679 |
| 2009 7 9 | 1 OCC 2 P | | 20 50 51. | | 20 53 51. | 20 55 12. | | 20 56 51. | | 0.177 | 0.167 | 0.161 | 360 | 358 | 11.3 | 0.608 |
| 2009 7 11 | 1 ECL 3 A | 9 8 12. | 9 9 54. | | 9 11 53. | 9 11 43. | | 9 13 51. | 9 15 34. | 0.440 | 0.440 | 0.436 | 237 | 236 | 6.8 | 0.204 |
| 2009 7 12 | 2 ECL 1 | 1 15 52. | | | 1 16 60. | 1 17 6. | | | 1 18 7. | 0.018 | 0.018 | 0.021 | | | 4.4 | 1.044 |
| 2009 7 13 | 1 ECL 2 P | 8 36 34. | 8 38 19. | | 8 39 53. | 8 40 18. | | 8 41 20. | 8 43 10. | 0.223 | 0.223 | 0.235 | 181 | 189 | 11.7 | 0.630 |
| 2009 7 13 | 1 OCC 2 P | | 9 55 19. | | 9 58 26. | 9 59 49. | | 10 1 35. | | 0.185 | 0.174 | 0.169 | 377 | 375 | 11.4 | 0.596 |
| 2009 7 14 | 3 ECL 2 | 10 43 0. | | | 10 47 32. | 10 47 32. | | | 10 52 3. | 0.150 | 0.150 | 0.134 | | | 14.2 | 1.046 |
| 2009 7 14 | 3 OCC 2 P | | 13 24 16. | | 13 26 2. | 13 24 34. | | 13 27 48. | | 0.005 | 0.005 | 0.009 | 213 | 253 | 13.7 | 1.329 |
| 2009 7 15 | 3 ECL 4 | 2 20 18. | | | 2 25 21. | 2 25 32. | | | 2 30 22. | 0.167 | 0.167 | 0.165 | | | 6.7 | 1.404 |
| 2009 7 15 | 2 ECL 4 | 7 30 59. | | | 7 35 32. | 7 35 51. | | | 7 40 6. | 0.357 | 0.357 | 0.346 | | | 5.3 | 0.620 |
| 2009 7 15 | 3 ECL 1 A | 11 19 16. | 11 21 0. | | 11 23 14. | 11 23 13. | | 11 25 28. | 11 27 12. | 0.598 | 0.598 | 0.598 | 268 | 268 | 8.4 | 0.015 |
| 2009 7 15 | 2 ECL 1 | 14 21 38. | | | 14 23 2. | 14 23 8. | | | 14 24 26. | 0.044 | 0.044 | 0.049 | | | 4.0 | 0.958 |
| 2009 7 16 | 1 ECL 2 P | 21 48 2. | 21 49 41. | | 21 51 34. | 21 51 59. | | 21 53 24. | 21 55 5. | 0.268 | 0.268 | 0.280 | 222 | 229 | 11.8 | 0.586 |
| 2009 7 16 | 1 OCC 2 P | | 23 0 15. | | 23 3 33. | 23 4 59. | | 23 6 53. | | 0.197 | 0.186 | 0.181 | 398 | 396 | 11.5 | 0.576 |
| 2009 7 18 | 1 ECL 3 A | 11 55 25. | 11 57 8. | | 11 59 18. | 11 59 7. | | 12 1 29. | 12 3 12. | 0.478 | 0.478 | 0.478 | 261 | 260 | 7.9 | 0.001 |
| 2009 7 19 | 2 ECL 1 | 3 27 25. | | | 3 29 2. | 3 29 8. | | | 3 30 38. | 0.083 | 0.083 | 0.090 | | | 3.7 | 0.870 |
| 2009 7 20 | 1 ECL 2 P | 10 59 37. | 11 1 13. | | 11 3 22. | 11 3 48. | | 11 5 29. | 11 7 4. | 0.312 | 0.312 | 0.325 | 256 | 262 | 11.9 | 0.544 |
| 2009 7 20 | 1 OCC 2 P | | 12 4 45. | | 12 8 14. | 12 9 41. | | 12 11 45. | | 0.212 | 0.201 | 0.195 | 421 | 419 | 11.5 | 0.549 |
| 2009 7 21 | 3 ECL 2 P | 14 17 28. | 14 21 19. | | 14 23 23. | 14 23 21. | | 14 25 30. | 14 29 22. | 0.322 | 0.322 | 0.302 | 250 | 223 | 13.9 | 0.795 |
| 2009 7 21 | 3 OCC 2 P | | 16 30 55. | | 16 33 13. | 16 31 58. | | 16 35 32. | | 0.010 | 0.009 | 0.013 | 277 | 315 | 13.0 | 1.318 |
| 2009 7 22 | 3 ECL 1 P | 14 7 24. | 14 9 8. | | 14 11 8. | 14 11 7. | | 14 13 9. | 14 14 52. | 0.662 | 0.662 | 0.662 | 241 | 241 | 7.0 | 0.220 |
| 2009 7 22 | 2 ECL 1 | 16 33 16. | | | 16 35 3. | 16 35 10. | | | 16 36 50. | 0.135 | 0.135 | 0.144 | | | 3.3 | 0.783 |
| 2009 7 23 | 4 ECL 2 | 23 8 2. | | | 23 11 56. | 23 12 35. | | | 23 15 52. | 0.157 | 0.157 | 0.139 | | | 12.1 | 1.205 |
| 2009 7 24 | 1 ECL 2 P | 0 12 20. | 0 13 54. | | 0 16 19. | 0 16 46. | | 0 18 43. | 0 20 16. | 0.354 | 0.354 | 0.367 | 289 | 294 | 11.9 | 0.507 |
| 2009 7 24 | 1 OCC 2 P | | 1 9 56. | | 1 13 39. | 1 15 9. | | 1 17 24. | | 0.232 | 0.219 | 0.214 | 448 | 446 | 11.6 | 0.514 |
| 2009 7 24 | 4 ECL 3 | 17 1 4. | | | 17 9 17. | 17 9 21. | | | 17 17 30. | 0.276 | 0.276 | 0.277 | | | 10.1 | 0.972 |
| 2009 7 25 | 1 ECL 3 A | 14 45 45. | 14 47 32. | | 14 49 51. | 14 49 38. | | 14 52 10. | 14 53 58. | 0.435 | 0.435 | 0.440 | 278 | 279 | 8.9 | 0.184 |
| 2009 7 26 | 2 ECL 1 | 5 39 9. | | | 5 41 4. | 5 41 10. | | | 5 42 58. | 0.181 | 0.181 | 0.187 | | | 2.9 | 0.695 |
| 2009 7 27 | 1 ECL 2 P | 13 25 14. | 13 26 48. | | 13 29 27. | 13 29 55. | | 13 32 5. | 13 33 41. | 0.393 | 0.393 | 0.406 | 317 | 322 | 12.0 | 0.474 |
| 2009 7 27 | 1 OCC 2 P | | 14 14 44. | | 14 18 41. | 14 20 13. | | 14 22 41. | | 0.254 | 0.240 | 0.235 | 477 | 476 | 11.6 | 0.474 |
| 2009 7 28 | 3 ECL 2 P | 17 57 24. | 18 0 33. | | 18 4 40. | 18 4 36. | | 18 8 50. | 18 11 60. | 0.594 | 0.594 | 0.570 | 497 | 484 | 13.0 | 0.550 |
| 2009 7 28 | 3 OCC 2 P | | 19 38 35. | | 19 41 49. | 19 40 50. | | 19 45 3. | | 0.021 | 0.020 | 0.025 | 388 | 422 | 12.0 | 1.268 |
| 2009 7 29 | 3 ECL 1 P | 16 53 33. | 16 55 22. | | 16 57 1. | 16 57 0. | | 16 58 39. | 17 0 28. | 0.579 | 0.579 | 0.579 | 197 | 197 | 5.5 | 0.462 |

**Table 6.** Mutual events occurring from July 31 to August 25, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 7 31 | 1 ECL 2 P | 2 39 34. | 2 41 8. | | 2 44 3. | 2 44 31. | | 2 46 58. | 2 48 34. | 0.427 | 0.427 | 0.441 | 350 | 355 | 12.0 | 0.446 |
| 2009 7 31 | 1 OCC 2 P | | 3 20 30. | | 3 24 44. | 3 26 18. | | 3 29 1. | | 0.281 | 0.265 | 0.260 | 512 | 511 | 11.7 | 0.426 |
| 2009 8 1 | 1 ECL 3 A | 17 39 45. | 17 41 41. | | 17 44 7. | 17 43 51. | | 17 46 31. | 17 48 29. | 0.356 | 0.356 | 0.363 | 290 | 292 | 9.8 | 0.346 |
| 2009 8 3 | 1 ECL 2 P | 15 54 13. | 15 55 51. | | 15 59 2. | 15 59 32. | | 16 2 16. | 16 3 53. | 0.457 | 0.457 | 0.471 | 385 | 389 | 12.0 | 0.423 |
| 2009 8 3 | 1 OCC 2 P | | 16 26 2. | | 16 30 35. | 16 32 12. | | 16 35 11. | | 0.310 | 0.293 | 0.288 | 549 | 548 | 11.7 | 0.373 |
| 2009 8 4 | 3 ECL 2 P | 21 45 19. | 21 48 19. | | 21 53 59. | 21 53 51. | | 21 59 42. | 22 2 44. | 0.792 | 0.792 | 0.778 | 683 | 675 | 11.7 | 0.310 |
| 2009 8 4 | 3 OCC 2 P | | 22 49 42. | | 22 54 6. | 22 53 29. | | 22 58 32. | | 0.041 | 0.038 | 0.045 | 530 | 561 | 10.9 | 1.187 |
| 2009 8 5 | 3 ECL 1 P | 19 38 38. | 19 40 45. | | 19 41 47. | 19 41 47. | | 19 42 50. | 19 44 56. | 0.418 | 0.418 | 0.419 | 125 | 125 | 3.9 | 0.707 |
| 2009 8 7 | 1 ECL 2 P | 5 10 48. | 5 12 25. | | 5 15 59. | 5 16 30. | | 5 19 33. | 5 21 13. | 0.480 | 0.480 | 0.493 | 428 | 432 | 11.9 | 0.406 |
| 2009 8 7 | 1 OCC 2 P | | 5 32 55. | | 5 37 49. | 5 39 29. | | 5 42 47. | | 0.343 | 0.324 | 0.319 | 592 | 592 | 11.7 | 0.311 |
| 2009 8 8 | 1 ECL 3 A | 20 39 40. | 20 41 50. | | 20 44 25. | 20 44 5. | | 20 47 2. | 20 49 12. | 0.302 | 0.302 | 0.306 | 311 | 312 | 10.6 | 0.477 |
| 2009 8 10 | 1 ECL 2 P | 18 28 9. | 18 29 49. | | 18 33 45. | 18 34 17. | | 18 37 42. | 18 39 25. | 0.508 | 0.508 | 0.522 | 473 | 478 | 11.9 | 0.394 |
| 2009 8 10 | 1 OCC 2 P | | 18 39 51. | | 18 45 7. | 18 46 50. | | 18 50 30. | | 0.378 | 0.357 | 0.352 | 639 | 640 | 11.7 | 0.247 |
| 2009 8 12 | 3 ECL 2 T | 1 43 56. | 1 47 3. | 1 53 50. | 1 54 14. | 1 54 2. | 1 54 39. | 2 1 32. | 2 4 42. | 1.000 | 1.000 | 0.996 | 869 | 865 | 9.8 | 0.073 |
| 2009 8 12 | 3 OCC 2 P | | 2 5 60. | | 2 11 48. | 2 11 39. | | 2 17 41. | | 0.067 | 0.063 | 0.071 | 701 | 731 | 9.5 | 1.088 |
| 2009 8 12 | 3 ECL 1 | 22 22 41. | | | 22 25 27. | 22 25 27. | | | 22 28 14. | 0.280 | 0.280 | 0.282 | | | 2.2 | 0.951 |
| 2009 8 14 | 1 ECL 2 P | 7 48 9. | 7 49 54. | | 7 54 17. | 7 54 51. | | 7 58 42. | 8 0 31. | 0.514 | 0.514 | 0.528 | 528 | 533 | 11.7 | 0.390 |
| 2009 8 14 | 1 OCC 2 P | | 7 48 34. | | 7 54 19. | 7 56 6. | | 8 0 10. | | 0.416 | 0.392 | 0.388 | 696 | 698 | 11.7 | 0.175 |
| 2009 8 14 | 1 OCC 2 P | | 21 49 41. | | 21 58 32. | 21 59 11. | | 22 8 18. | | 0.006 | 0.006 | 0.009 | 1116 | 1307 | 6.6 | 1.102 |
| 2009 8 15 | 1 OCC 2 P | | 0 27 54. | | 0 49 4. | 0 47 16. | | 1 5 38. | | 0.091 | 0.086 | 0.090 | 2264 | 2339 | 10.1 | 0.827 |
| 2009 8 15 | 1 ECL 2 | | | | 0 48 35. | 0 50 6. | | | | 0.0 | 0.0 | 0.000 | 0 | | 11.7 | 1.0 |
| 2009 8 15 | 1 ECL 3 P | 23 49 6. | 23 51 39. | | 23 54 35. | 23 54 9. | | 23 57 33. | 0 0 5. | 0.276 | 0.276 | 0.282 | 355 | 359 | 11.1 | 0.571 |
| 2009 8 16 | 1 ECL 3 A | 16 24 9. | 16 29 34. | | 16 46 11. | 16 49 36. | | 17 4 57. | 17 12 12. | 0.438 | 0.438 | 0.436 | 2123 | 2169 | 7.0 | 0.178 |
| 2009 8 16 | 1 OCC 3 P | | 16 53 0. | | 17 9 16. | 17 17 18. | | 17 28 15. | | 0.052 | 0.079 | 0.075 | 2115 | 2274 | 7.8 | 1.098 |
| 2009 8 16 | 1 OCC 3 P | | 20 17 57. | | 20 22 32. | 20 13 31. | | 20 26 54. | | 0.001 | 0.002 | 0.003 | 537 | 716 | 10.8 | 1.492 |
| 2009 8 16 | 1 ECL 3 A | 20 25 49. | 20 33 53. | | 20 48 17. | 20 45 56. | | 21 0 54. | 21 6 52. | 0.334 | 0.334 | 0.333 | 1622 | 1662 | 11.1 | 0.429 |
| 2009 8 17 | 1 OCC 2 P | | 20 57 46. | | 21 4 2. | 21 5 53. | | 21 10 26. | | 0.448 | 0.423 | 0.420 | 760 | 762 | 11.6 | 0.100 |
| 2009 8 17 | 1 ECL 2 P | 21 9 45. | 21 11 38. | | 21 16 33. | 21 17 9. | | 21 21 32. | 21 23 29. | 0.511 | 0.511 | 0.525 | 594 | 601 | 11.6 | 0.394 |
| 2009 8 18 | 1 OCC 2 P | | 14 27 31. | | 14 39 7. | 14 37 59. | | 14 49 48. | | 0.135 | 0.127 | 0.132 | 1337 | 1358 | 10.8 | 0.725 |
| 2009 8 18 | 1 ECL 2 | 14 53 1. | | | 14 59 48. | 15 0 41. | | | 15 6 26. | 0.029 | 0.029 | 0.035 | | | 11.0 | 0.893 |
| 2009 8 19 | 3 OCC 2 P | | 5 32 36. | | 5 40 13. | 5 40 39. | | 5 47 57. | | 0.097 | 0.090 | 0.099 | 921 | 952 | 7.9 | 0.986 |
| 2009 8 19 | 3 ECL 2 P | 6 1 25. | 6 5 0. | | 6 14 8. | 6 13 49. | | 6 23 27. | 6 27 9. | 0.939 | 0.939 | 0.969 | 1107 | 1110 | 7.4 | 0.169 |
| 2009 8 20 | 3 ECL 2 | 17 43 46. | | | 17 53 31. | 17 52 50. | | | 18 3 3. | 0.051 | 0.051 | 0.045 | | | 5.1 | 1.124 |
| 2009 8 21 | 1 OCC 2 T | | 10 9 41. | 10 16 5. | 10 16 36. | 10 18 33. | 10 17 7. | 10 23 43. | | 0.450 | 0.425 | 0.425 | 842 | 846 | 11.6 | 0.003 |
| 2009 8 21 | 1 ECL 2 P | 10 35 50. | 10 37 53. | | 10 43 34. | 10 44 13. | | 10 49 20. | 10 51 31. | 0.491 | 0.491 | 0.505 | 687 | 694 | 11.3 | 0.411 |
| 2009 8 22 | 1 OCC 2 P | | 4 1 36. | | 4 10 32. | 4 9 32. | | 4 19 2. | | 0.163 | 0.154 | 0.159 | 1046 | 1058 | 11.2 | 0.662 |
| 2009 8 22 | 1 ECL 2 P | 4 36 56. | 4 41 31. | | 4 43 31. | 4 44 12. | | 4 45 19. | 4 50 1. | 0.079 | 0.079 | 0.086 | 228 | 269 | 11.5 | 0.791 |
| 2009 8 23 | 1 ECL 3 P | 3 17 3. | 3 20 13. | | 3 24 12. | 3 23 30. | | 3 28 17. | 3 31 29. | 0.255 | 0.255 | 0.262 | 483 | 489 | 11.3 | 0.609 |
| 2009 8 24 | 1 ECL 3 P | 1 23 28. | 1 27 24. | | 1 30 19. | 1 29 38. | | 1 33 10. | 1 36 59. | 0.159 | 0.159 | 0.156 | 346 | 342 | 12.2 | 0.808 |
| 2009 8 24 | 1 OCC 2 T | | 23 22 56. | 23 30 18. | 23 30 38. | 23 32 43. | 23 30 58. | 23 38 37. | | 0.450 | 0.425 | 0.425 | 941 | 947 | 11.5 | 0.003 |
| 2009 8 25 | 1 ECL 2 P | 0 5 58. | 0 8 20. | | 0 15 3. | 0 15 49. | | 0 21 60. | 0 24 33. | 0.454 | 0.454 | 0.468 | 820 | 831 | 10.9 | 0.440 |

**Table 7.** Mutual events occurring from August 25 to September 20, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 8 25 | 1 OCC 2 P | | 17 24 12. | | 17 31 46. | 17 30 54. | | 17 39 4. | | 0.180 | 0.170 | 0.175 | 892 | 901 | 11.4 | 0.625 |
| 2009 8 25 | 1 ECL 2 P | 18 8 48. | 18 11 49. | | 18 15 6. | 18 15 42. | | 18 18 25. | 18 21 20. | 0.153 | 0.153 | 0.163 | 396 | 412 | 11.9 | 0.700 |
| 2009 8 26 | 3 OCC 2 P | | 9 15 24. | | 9 25 39. | 9 26 55. | | 9 36 10. | | 0.122 | 0.113 | 0.123 | 1246 | 1283 | 6.0 | 0.903 |
| 2009 8 26 | 3 ECL 2 P | 10 55 22. | 11 0 19. | | 11 13 2. | 11 12 29. | | 11 26 17. | 11 31 39. | 0.762 | 0.762 | 0.786 | 1558 | 1577 | 4.5 | 0.435 |
| 2009 8 27 | 3 ECL 2 | 0 58 23. | | | 1 3 36. | 1 4 55. | | | 1 8 37. | 0.001 | 0.001 | 0.004 | | | 0.3 | 1.230 |
| 2009 8 27 | 3 ECL 2 | 22 43 5. | | | 22 49 49. | 22 49 27. | | | 22 56 32. | 0.055 | 0.055 | 0.047 | | | 8.0 | 1.134 |
| 2009 8 28 | 1 OCC 2 P | | 12 40 49. | | 12 49 40. | 12 51 55. | | 12 58 56. | | 0.417 | 0.394 | 0.398 | 1087 | 1096 | 11.2 | 0.170 |
| 2009 8 28 | 1 ECL 2 P | 13 46 53. | 13 49 55. | | 13 58 36. | 13 59 32. | | 14 7 51. | 14 11 17. | 0.383 | 0.383 | 0.396 | 1075 | 1095 | 10.3 | 0.496 |
| 2009 8 29 | 1 OCC 2 P | | 6 43 26. | | 6 50 3. | 6 49 15. | | 6 56 30. | | 0.193 | 0.182 | 0.187 | 784 | 791 | 11.6 | 0.597 |
| 2009 8 29 | 1 ECL 2 P | 7 36 18. | 7 38 40. | | 7 42 19. | 7 42 53. | | 7 46 0. | 7 48 18. | 0.245 | 0.245 | 0.256 | 440 | 449 | 12.1 | 0.611 |
| 2009 8 30 | 1 OCC 3 P | | 5 43 19. | | 5 46 38. | 5 48 8. | | 5 49 60. | | 0.009 | 0.015 | 0.018 | 401 | 433 | 11.7 | 1.378 |
| 2009 8 30 | 1 ECL 3 P | 7 43 26. | 7 49 18. | | 8 0 5. | 7 57 59. | | 8 12 2. | 8 19 20. | 0.290 | 0.290 | 0.296 | 1365 | 1348 | 10.2 | 0.534 |
| 2009 8 30 | 1 ECL 3 A | 12 3 32. | 12 10 2. | | 12 26 40. | 12 29 47. | | 12 41 51. | 12 47 2. | 0.395 | 0.395 | 0.400 | 1909 | 1885 | 5.3 | 0.288 |
| 2009 8 30 | 1 OCC 3 P | | 14 24 19. | | 14 35 16. | 14 36 55. | | 14 46 4. | | 0.144 | 0.222 | 0.225 | 1304 | 1315 | 2.2 | 0.632 |
| 2009 8 31 | 1 ECL 3 | 4 58 2. | | | 5 1 59. | 5 1 33. | | | 5 5 54. | 0.058 | 0.058 | 0.056 | | | 11.9 | 1.132 |
| 2009 9 1 | 1 OCC 2 P | | 2 2 19. | | 2 12 49. | 2 15 23. | | 2 24 2. | | 0.360 | 0.340 | 0.344 | 1303 | 1320 | 10.9 | 0.277 |
| 2009 9 1 | 1 ECL 2 P | 3 48 47. | 3 54 27. | | 4 8 53. | 4 10 39. | | 4 27 7. | 4 35 55. | 0.251 | 0.251 | 0.262 | 1959 | 2069 | 9.1 | 0.606 |
| 2009 9 1 | 1 ECL 2 | 6 45 13. | | | 7 2 25. | 7 0 43. | | | 7 15 52. | 0.023 | 0.023 | 0.029 | | | 5.4 | 0.890 |
| 2009 9 1 | 1 OCC 2 P | | 8 49 53. | | 8 51 31. | 8 50 20. | | 8 53 9. | | 0.000 | 0.000 | 0.002 | 196 | 414 | 2.7 | 1.136 |
| 2009 9 1 | 1 OCC 2 P | | 19 58 8. | | 20 4 6. | 20 3 22. | | 20 9 55. | | 0.199 | 0.188 | 0.192 | 707 | 713 | 11.7 | 0.583 |
| 2009 9 1 | 1 ECL 2 P | 20 58 56. | 21 0 57. | | 21 4 44. | 21 5 16. | | 21 8 26. | 21 10 24. | 0.337 | 0.337 | 0.349 | 449 | 460 | 12.2 | 0.526 |
| 2009 9 2 | 3 OCC 2 P | | 13 35 6. | | 13 50 56. | 13 53 38. | | 14 7 42. | | 0.128 | 0.119 | 0.128 | 1955 | 2020 | 3.7 | 0.876 |
| 2009 9 4 | 3 ECL 2 | 3 2 49. | | | 3 7 45. | 3 7 32. | | | 3 12 38. | 0.036 | 0.036 | 0.029 | | | 10.2 | 1.189 |
| 2009 9 4 | 1 OCC 2 P | | 15 35 1. | | 15 48 53. | 15 52 8. | | 16 4 34. | | 0.286 | 0.270 | 0.273 | 1774 | 1815 | 10.3 | 0.413 |
| 2009 9 4 | 1 OCC 2 P | | 20 24 14. | | 20 32 26. | 20 30 34. | | 20 40 20. | | 0.015 | 0.014 | 0.019 | 966 | 1082 | 4.5 | 1.043 |
| 2009 9 5 | 1 OCC 2 P | | 9 11 57. | | 9 17 22. | 9 16 40. | | 9 22 41. | | 0.202 | 0.191 | 0.196 | 644 | 649 | 11.8 | 0.574 |
| 2009 9 5 | 1 ECL 2 P | 10 19 59. | 10 21 45. | | 10 25 32. | 10 26 2. | | 10 29 16. | 10 31 1. | 0.443 | 0.443 | 0.455 | 451 | 455 | 12.3 | 0.439 |
| 2009 9 6 | 1 OCC 3 P | | 10 2 38. | | 10 27 4. | 10 29 45. | | 12 58 40. | | 0.094 | 0.145 | 0.152 | 10562 | 10488 | 7.7 | 0.859 |
| 2009 9 7 | 1 ECL 3 | 8 11 53. | | | 8 13 21. | 8 13 2. | | | 8 14 54. | 0.003 | 0.003 | 0.002 | | | 11.3 | 1.446 |
| 2009 9 8 | 1 OCC 2 P | | 5 30 18. | | 5 57 60. | 6 5 18. | | 5 30 17. | | 0.175 | 0.165 | 0.164 | 0 | 8892 | 9.9 | 0.625 |
| 2009 9 8 | 1 OCC 2 P | | 22 23 13. | | 22 28 13. | 22 27 33. | | 22 33 7. | | 0.201 | 0.190 | 0.195 | 594 | 599 | 11.8 | 0.572 |
| 2009 9 8 | 1 ECL 2 P | 23 38 12. | 23 39 49. | | 23 43 33. | 23 44 2. | | 23 47 15. | 23 48 50. | 0.549 | 0.549 | 0.561 | 447 | 449 | 12.3 | 0.354 |
| 2009 9 11 | 3 ECL 2 | 7 4 38. | | | 7 7 53. | 7 7 44. | | | 7 11 5. | 0.013 | 0.013 | 0.009 | | | 12.0 | 1.277 |
| 2009 9 12 | 1 OCC 2 P | | 11 34 25. | | 11 39 2. | 11 38 24. | | 11 43 35. | | 0.199 | 0.188 | 0.193 | 550 | 555 | 11.8 | 0.572 |
| 2009 9 12 | 1 ECL 2 P | 12 55 43. | 12 57 13. | | 13 0 51. | 13 1 18. | | 13 4 29. | 13 5 58. | 0.653 | 0.653 | 0.664 | 436 | 438 | 12.3 | 0.267 |
| 2009 9 16 | 1 OCC 2 P | | 0 43 58. | | 0 48 16. | 0 47 41. | | 0 52 32. | | 0.195 | 0.184 | 0.189 | 514 | 518 | 11.8 | 0.577 |
| 2009 9 16 | 1 ECL 2 P | 2 11 19. | 2 12 44. | | 2 16 16. | 2 16 43. | | 2 19 48. | 2 21 12. | 0.734 | 0.734 | 0.741 | 424 | 425 | 12.3 | 0.181 |
| 2009 9 18 | 3 ECL 2 | 10 57 22. | | | 10 57 29. | 10 57 33. | | | 10 58 2. | 0.000 | 0.000 | 0.0 | | 0 | 13.2 | 1.392 |
| 2009 9 19 | 1 OCC 2 P | | 13 53 44. | | 13 57 46. | 13 57 12. | | 14 1 45. | | 0.190 | 0.179 | 0.184 | 481 | 485 | 11.8 | 0.583 |
| 2009 9 19 | 1 ECL 2 P | 15 26 34. | 15 27 55. | | 15 31 18. | 15 31 44. | | 15 34 42. | 15 36 0. | 0.768 | 0.768 | 0.769 | 407 | 408 | 12.3 | 0.092 |
| 2009 9 20 | 2 ECL 1 | 23 18 43. | | | 23 20 38. | 23 20 46. | | | 23 22 33. | 0.181 | 0.181 | 0.175 | | | 3.5 | 0.698 |

**Table 8.** Mutual events occurring from September 21 to October 25, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 9 21 | 2 OCC 3 P | | 0 47 59. | | 0 50 36. | 0 49 21. | | 0 53 14. | | 0.141 | 0.219 | 0.217 | 315 | 313 | 1.8 | 0.530 |
| 2009 9 23 | 1 OCC 2 P | | 3 2 25. | | 3 6 12. | 3 5 40. | | 3 9 57. | | 0.183 | 0.173 | 0.178 | 452 | 456 | 11.7 | 0.590 |
| 2009 9 23 | 1 ECL 2 A | 4 40 25. | 4 41 45. | | 4 44 58. | 4 45 23. | | 4 48 10. | 4 49 28. | 0.742 | 0.742 | 0.742 | 385 | 385 | 12.2 | 0.004 |
| 2009 9 24 | 2 ECL 1 | 12 25 22. | | | 12 27 9. | 12 27 17. | | | 12 28 57. | 0.140 | 0.140 | 0.131 | | | 3.9 | 0.779 |
| 2009 9 25 | 3 OCC 2 P | | 11 8 51. | | 11 11 12. | 11 12 16. | | 11 13 32. | | 0.009 | 0.008 | 0.006 | 281 | 258 | 12.4 | 1.278 |
| 2009 9 26 | 1 OCC 2 P | | 16 11 30. | | 16 15 4. | 16 14 33. | | 16 18 36. | | 0.177 | 0.167 | 0.172 | 426 | 430 | 11.7 | 0.597 |
| 2009 9 26 | 1 ECL 2 P | 17 54 6. | 17 55 25. | | 17 58 27. | 17 58 51. | | 18 1 27. | 18 2 45. | 0.752 | 0.752 | 0.751 | 363 | 362 | 12.1 | 0.086 |
| 2009 9 28 | 2 ECL 1 | 1 32 6. | | | 1 33 44. | 1 33 52. | | | 1 35 23. | 0.090 | 0.090 | 0.083 | | | 4.2 | 0.860 |
| 2009 9 28 | 2 OCC 3 A | | 3 39 33. | | 3 42 21. | 3 40 55. | | 3 45 9. | | 0.168 | 0.261 | 0.261 | 336 | 335 | 2.2 | 0.277 |
| 2009 9 28 | 1 OCC 3 P | | 14 39 0. | | 14 39 13. | 14 38 4. | | 14 39 25. | | 0.000 | 0.000 | 0.000 | 24 | 36 | 8.7 | 1.425 |
| 2009 9 30 | 1 OCC 2 P | | 5 19 51. | | 5 23 13. | 5 22 44. | | 5 26 34. | | 0.171 | 0.161 | 0.166 | 403 | 407 | 11.6 | 0.604 |
| 2009 9 30 | 1 ECL 2 P | 7 6 44. | 7 8 3. | | 7 10 52. | 7 11 16. | | 7 13 41. | 7 14 58. | 0.715 | 0.715 | 0.709 | 338 | 336 | 12.0 | 0.177 |
| 2009 10 1 | 2 ECL 1 | 14 38 53. | | | 14 40 20. | 14 40 28. | | | 14 41 49. | 0.053 | 0.053 | 0.047 | | | 4.6 | 0.940 |
| 2009 10 1 | 3 OCC 1 | | | | 15 16 42. | 15 16 2. | | | | 0.0 | 0.0 | 0.000 | 0 | 40 | 5.5 | 1.4 |
| 2009 10 2 | 3 OCC 2 P | | 14 28 7. | | 14 31 39. | 14 32 59. | | 14 35 11. | | 0.041 | 0.038 | 0.035 | 425 | 414 | 13.4 | 1.101 |
| 2009 10 3 | 1 OCC 2 P | | 18 28 40. | | 18 31 52. | 18 31 24. | | 18 35 2. | | 0.165 | 0.156 | 0.161 | 383 | 386 | 11.5 | 0.608 |
| 2009 10 3 | 1 ECL 2 P | 20 19 19. | 20 20 38. | | 20 23 13. | 20 23 36. | | 20 25 47. | 20 27 6. | 0.635 | 0.635 | 0.625 | 309 | 307 | 11.9 | 0.270 |
| 2009 10 5 | 2 ECL 1 | 3 45 47. | | | 3 47 2. | 3 47 9. | | | 3 48 16. | 0.026 | 0.026 | 0.022 | | | 4.9 | 1.018 |
| 2009 10 5 | 2 OCC 3 A | | 6 34 33. | | 6 37 26. | 6 35 52. | | 6 40 18. | | 0.168 | 0.261 | 0.261 | 345 | 344 | 2.6 | 0.066 |
| 2009 10 5 | 1 OCC 3 P | | 17 16 8. | | 17 17 14. | 17 16 17. | | 17 18 20. | | 0.006 | 0.009 | 0.010 | 132 | 136 | 7.7 | 1.311 |
| 2009 10 7 | 1 OCC 2 P | | 7 36 54. | | 7 39 57. | 7 39 31. | | 7 42 59. | | 0.160 | 0.151 | 0.156 | 365 | 368 | 11.4 | 0.612 |
| 2009 10 7 | 1 ECL 2 P | 9 30 60. | 9 32 22. | | 9 34 40. | 9 35 3. | | 9 36 59. | 9 38 20. | 0.530 | 0.530 | 0.518 | 277 | 274 | 11.7 | 0.362 |
| 2009 10 8 | 2 ECL 1 | 16 52 50. | | | 16 53 45. | 16 53 52. | | | 16 54 39. | 0.009 | 0.009 | 0.007 | | | 5.2 | 1.095 |
| 2009 10 8 | 3 OCC 1 P | | 17 50 23. | | 17 51 53. | 17 51 6. | | 17 53 22. | | 0.026 | 0.027 | 0.030 | 179 | 184 | 6.7 | 1.202 |
| 2009 10 9 | 3 OCC 2 P | | 17 48 15. | | 17 52 17. | 17 53 49. | | 17 56 17. | | 0.083 | 0.077 | 0.072 | 482 | 475 | 14.0 | 0.937 |
| 2009 10 10 | 1 OCC 2 P | | 20 45 41. | | 20 48 36. | 20 48 11. | | 20 51 30. | | 0.157 | 0.148 | 0.153 | 349 | 352 | 11.3 | 0.612 |
| 2009 10 10 | 1 ECL 2 P | 22 42 43. | 22 44 9. | | 22 46 7. | 22 46 30. | | 22 48 7. | 22 49 33. | 0.418 | 0.418 | 0.406 | 238 | 235 | 11.6 | 0.457 |
| 2009 10 12 | 2 ECL 1 | 6 0 4. | | | 6 0 31. | 6 0 38. | | | 6 0 57. | 0.001 | 0.001 | 0.000 | | | 5.5 | 1.171 |
| 2009 10 12 | 2 OCC 3 A | | 9 33 14. | | 9 36 7. | 9 34 26. | | 9 39 1. | | 0.168 | 0.261 | 0.261 | 347 | 346 | 2.8 | 0.095 |
| 2009 10 14 | 1 OCC 2 P | | 9 54 4. | | 9 56 52. | 9 56 28. | | 9 59 39. | | 0.155 | 0.146 | 0.151 | 335 | 338 | 11.2 | 0.610 |
| 2009 10 14 | 1 ECL 2 P | 11 53 42. | 11 55 13. | | 11 56 51. | 11 57 14. | | 11 58 28. | 12 0 1. | 0.311 | 0.311 | 0.301 | 196 | 191 | 11.5 | 0.553 |
| 2009 10 15 | 3 OCC 1 P | | 20 29 22. | | 20 31 27. | 20 30 33. | | 20 33 31. | | 0.065 | 0.067 | 0.071 | 250 | 254 | 7.8 | 1.022 |
| 2009 10 16 | 3 OCC 2 P | | 21 8 51. | | 21 13 4. | 21 14 41. | | 21 17 15. | | 0.124 | 0.115 | 0.110 | 504 | 498 | 14.4 | 0.796 |
| 2009 10 17 | 1 OCC 2 P | | 23 2 60. | | 23 5 42. | 23 5 19. | | 23 8 23. | | 0.155 | 0.146 | 0.151 | 324 | 327 | 11.1 | 0.603 |
| 2009 10 18 | 1 ECL 2 P | 1 4 43. | 1 6 32. | | 1 7 38. | 1 7 59. | | 1 8 44. | 1 10 30. | 0.215 | 0.215 | 0.206 | 131 | 124 | 11.3 | 0.650 |
| 2009 10 19 | 2 OCC 3 A | | 12 35 53. | | 12 38 46. | 12 37 1. | | 12 41 39. | | 0.168 | 0.261 | 0.261 | 346 | 346 | 2.9 | 0.203 |
| 2009 10 21 | 1 OCC 2 P | | 12 11 36. | | 12 14 14. | 12 13 53. | | 12 16 50. | | 0.156 | 0.148 | 0.152 | 314 | 317 | 11.0 | 0.593 |
| 2009 10 21 | 1 ECL 2 | 14 15 11. | | | 14 17 46. | 14 18 8. | | | 14 20 20. | 0.148 | 0.148 | 0.144 | | | 11.1 | 0.747 |
| 2009 10 22 | 3 OCC 1 P | | 23 14 10. | | 23 16 43. | 23 15 41. | | 23 19 17. | | 0.102 | 0.105 | 0.110 | 307 | 310 | 8.9 | 0.877 |
| 2009 10 24 | 3 OCC 2 P | | 0 30 41. | | 0 34 55. | 0 36 33. | | 0 39 7. | | 0.160 | 0.149 | 0.143 | 506 | 501 | 14.5 | 0.682 |
| 2009 10 25 | 1 OCC 2 P | | 1 20 45. | | 1 23 19. | 1 22 59. | | 1 25 51. | | 0.160 | 0.152 | 0.156 | 306 | 309 | 10.8 | 0.579 |

**Table 9.** Mutual events occurring from October 25 to November 28, 2009.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 10 25 | 1 ECL 2 | 3 25 42. | | | 3 27 56. | 3 28 18. | | | 3 30 9. | 0.093 | 0.093 | 0.086 | | | 10.9 | 0.847 |
| 2009 10 26 | 2 OCC 3 A | | 15 42 8. | | 15 45 1. | 15 43 15. | | 15 47 54. | | 0.168 | 0.261 | 0.261 | 346 | 346 | 2.8 | 0.258 |
| 2009 10 28 | 1 OCC 2 P | | 14 29 41. | | 14 32 11. | 14 31 53. | | 14 34 41. | | 0.167 | 0.158 | 0.162 | 300 | 303 | 10.7 | 0.561 |
| 2009 10 28 | 1 ECL 2 | 16 35 48. | | | 16 37 36. | 16 37 57. | | | 16 39 22. | 0.039 | 0.039 | 0.035 | | | 10.8 | 0.946 |
| 2009 10 30 | 3 OCC 1 P | | 2 6 8. | | 2 9 11. | 2 7 60. | | 2 12 14. | | 0.133 | 0.138 | 0.144 | 367 | 370 | 9.9 | 0.765 |
| 2009 10 30 | 3 ECL 1 | 20 9 38. | | | 20 15 41. | 20 17 5. | | | 20 21 27. | 0.013 | 0.013 | 0.012 | | | 5.9 | 1.285 |
| 2009 10 31 | 3 OCC 2 P | | 3 54 9. | | 3 58 17. | 3 59 51. | | 4 2 25. | | 0.186 | 0.172 | 0.166 | 496 | 491 | 14.3 | 0.601 |
| 2009 11 1 | 1 OCC 2 P | | 3 39 7. | | 3 41 36. | 3 41 18. | | 3 44 3. | | 0.177 | 0.167 | 0.172 | 296 | 298 | 10.5 | 0.537 |
| 2009 11 1 | 1 ECL 2 | 5 46 8. | | | 5 47 18. | 5 47 38. | | | 5 48 29. | 0.009 | 0.009 | 0.007 | | | 10.6 | 1.047 |
| 2009 11 2 | 2 OCC 3 A | | 18 52 15. | | 18 55 11. | 18 53 25. | | 18 58 6. | | 0.168 | 0.261 | 0.261 | 350 | 350 | 2.5 | 0.261 |
| 2009 11 3 | 1 OCC 3 P | | 3 56 35. | | 3 57 58. | 3 57 39. | | 3 59 21. | | 0.020 | 0.030 | 0.032 | 166 | 170 | 2.9 | 1.097 |
| 2009 11 4 | 1 OCC 2 P | | 16 48 25. | | 16 50 52. | 16 50 35. | | 16 53 18. | | 0.189 | 0.179 | 0.184 | 293 | 295 | 10.4 | 0.509 |
| 2009 11 5 | 2 OCC 1 P | | 23 51 16. | | 23 53 10. | 23 52 56. | | 23 55 4. | | 0.394 | 0.419 | 0.424 | 228 | 228 | 4.4 | 0.095 |
| 2009 11 6 | 3 OCC 1 P | | 5 8 7. | | 5 11 48. | 5 10 25. | | 5 15 32. | | 0.160 | 0.165 | 0.171 | 445 | 447 | 10.9 | 0.676 |
| 2009 11 6 | 3 ECL 1 | 18 27 45. | | | 18 32 37. | 18 33 51. | | | 18 37 44. | 0.010 | 0.010 | 0.010 | | | 0.1 | 1.298 |
| 2009 11 7 | 3 OCC 2 P | | 7 19 22. | | 7 23 21. | 7 24 47. | | 7 27 19. | | 0.198 | 0.184 | 0.178 | 477 | 472 | 13.8 | 0.556 |
| 2009 11 8 | 1 OCC 2 P | | 5 58 8. | | 6 0 34. | 6 0 19. | | 6 2 59. | | 0.206 | 0.195 | 0.199 | 291 | 293 | 10.2 | 0.475 |
| 2009 11 9 | 2 OCC 1 P | | 12 58 3. | | 12 59 58. | 12 59 43. | | 13 1 53. | | 0.400 | 0.424 | 0.426 | 230 | 230 | 4.7 | 0.079 |
| 2009 11 9 | 2 OCC 3 A | | 22 5 31. | | 22 8 30. | 22 6 49. | | 22 11 29. | | 0.168 | 0.261 | 0.261 | 358 | 358 | 2.0 | 0.212 |
| 2009 11 11 | 1 OCC 2 P | | 19 7 47. | | 19 10 12. | 19 9 58. | | 19 12 37. | | 0.226 | 0.214 | 0.219 | 290 | 292 | 10.0 | 0.437 |
| 2009 11 13 | 2 OCC 1 A | | 2 5 13. | | 2 7 9. | 2 6 52. | | 2 9 5. | | 0.402 | 0.426 | 0.426 | 232 | 232 | 4.9 | 0.057 |
| 2009 11 13 | 3 OCC 1 P | | 8 26 15. | | 8 31 3. | 8 29 22. | | 8 35 55. | | 0.184 | 0.191 | 0.196 | 581 | 582 | 11.6 | 0.597 |
| 2009 11 13 | 3 OCC 1 T | | 22 22 15. | 22 33 4. | 22 35 2. | 22 35 32. | 22 36 59. | 22 48 9. | | 0.310 | 0.321 | 0.321 | 1553 | 1546 | 3.5 | 0.004 |
| 2009 11 14 | 3 OCC 1 P | | 6 11 38. | | 6 20 3. | 6 21 50. | | 6 28 7. | | 0.189 | 0.196 | 0.193 | 989 | 981 | 11.6 | 0.583 |
| 2009 11 14 | 3 OCC 2 P | | 10 46 42. | | 10 50 29. | 10 51 42. | | 10 54 15. | | 0.196 | 0.182 | 0.175 | 453 | 447 | 12.9 | 0.549 |
| 2009 11 15 | 1 OCC 2 P | | 8 17 50. | | 8 20 15. | 8 20 2. | | 8 22 40. | | 0.251 | 0.237 | 0.242 | 290 | 291 | 9.8 | 0.393 |
| 2009 11 16 | 2 OCC 1 A | | 15 12 49. | | 15 14 46. | 15 14 29. | | 15 16 43. | | 0.402 | 0.426 | 0.426 | 234 | 234 | 5.2 | 0.029 |
| 2009 11 17 | 2 OCC 3 A | | 1 22 8. | | 1 25 12. | 1 23 38. | | 1 28 16. | | 0.168 | 0.261 | 0.261 | 368 | 368 | 1.2 | 0.119 |
| 2009 11 18 | 1 OCC 2 P | | 21 27 51. | | 21 30 16. | 21 30 4. | | 21 32 41. | | 0.280 | 0.265 | 0.270 | 290 | 291 | 9.6 | 0.344 |
| 2009 11 20 | 2 OCC 1 A | | 4 20 48. | | 4 22 47. | 4 22 29. | | 4 24 45. | | 0.402 | 0.426 | 0.426 | 236 | 236 | 5.4 | 0.003 |
| 2009 11 20 | 3 OCC 1 P | | 12 17 42. | | 12 25 34. | 12 23 8. | | 12 33 44. | | 0.218 | 0.226 | 0.231 | 962 | 957 | 11.7 | 0.499 |
| 2009 11 20 | 3 OCC 1 T | | 20 33 47. | 20 44 32. | 20 46 24. | 20 47 58. | 20 48 16. | 20 58 45. | | 0.310 | 0.321 | 0.321 | 1498 | 1488 | 2.9 | 0.004 |
| 2009 11 21 | 3 OCC 1 P | | 10 15 12. | | 10 19 23. | 10 20 39. | | 10 23 32. | | 0.097 | 0.101 | 0.099 | 500 | 496 | 11.5 | 0.812 |
| 2009 11 21 | 3 OCC 2 P | | 14 15 18. | | 14 18 48. | 14 19 46. | | 14 22 19. | | 0.177 | 0.164 | 0.156 | 421 | 415 | 11.8 | 0.583 |
| 2009 11 22 | 1 OCC 2 P | | 10 38 14. | | 10 40 39. | 10 40 28. | | 10 43 3. | | 0.314 | 0.297 | 0.302 | 289 | 290 | 9.4 | 0.290 |
| 2009 11 23 | 2 OCC 1 A | | 17 29 13. | | 17 31 13. | 17 30 54. | | 17 33 12. | | 0.402 | 0.426 | 0.426 | 238 | 238 | 5.7 | 0.040 |
| 2009 11 24 | 2 OCC 3 A | | 4 41 60. | | 4 45 8. | 4 43 44. | | 4 48 16. | | 0.168 | 0.261 | 0.261 | 377 | 377 | 0.3 | 0.016 |
| 2009 11 25 | 1 OCC 2 P | | 23 48 35. | | 23 50 59. | 23 50 49. | | 23 53 23. | | 0.353 | 0.333 | 0.338 | 289 | 290 | 9.2 | 0.230 |
| 2009 11 27 | 2 OCC 1 P | | 6 38 2. | | 6 40 2. | 6 39 42. | | 6 42 2. | | 0.397 | 0.422 | 0.415 | 240 | 239 | 5.9 | 0.082 |
| 2009 11 28 | 3 OCC 1 P | | 13 43 32. | | 13 45 41. | 13 46 42. | | 13 47 50. | | 0.025 | 0.026 | 0.025 | 258 | 254 | 10.7 | 1.031 |
| 2009 11 28 | 3 OCC 2 P | | 17 45 36. | | 17 48 46. | 17 49 27. | | 17 51 55. | | 0.140 | 0.130 | 0.122 | 379 | 371 | 10.4 | 0.658 |

**Table 10.** Mutual events occurring from November 29, 2009 to April 7, 2010.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 11 29 | 1 OCC 2 P | | 12 59 16. | | 13 1 40. | 13 1 30. | | 13 4 3. | | 0.396 | 0.374 | 0.378 | 287 | 288 | 9.0 | 0.165 |
| 2009 11 30 | 2 OCC 1 P | | 19 47 13. | | 19 49 13. | 19 48 53. | | 19 51 14. | | 0.374 | 0.397 | 0.388 | 241 | 240 | 6.2 | 0.128 |
| 2009 12 1 | 2 OCC 3 A | | 8 5 9. | | 8 8 18. | 8 7 7. | | 8 11 28. | | 0.168 | 0.261 | 0.261 | 379 | 380 | 0.9 | 0.187 |
| 2009 12 3 | 1 OCC 2 P | | 2 9 57. | | 2 12 19. | 2 12 11. | | 2 14 42. | | 0.439 | 0.415 | 0.418 | 285 | 286 | 8.8 | 0.095 |
| 2009 12 4 | 2 OCC 1 P | | 8 56 48. | | 8 58 48. | 8 58 26. | | 9 0 49. | | 0.344 | 0.365 | 0.355 | 241 | 240 | 6.4 | 0.176 |
| 2009 12 5 | 3 OCC 2 P | | 21 16 58. | | 21 19 37. | 21 20 1. | | 21 22 16. | | 0.086 | 0.080 | 0.072 | 318 | 308 | 8.9 | 0.775 |
| 2009 12 6 | 1 OCC 2 T | | 15 20 55. | 15 23 6. | 15 23 16. | 15 23 9. | 15 23 26. | 15 25 37. | | 0.450 | 0.425 | 0.425 | 282 | 282 | 8.6 | 0.006 |
| 2009 12 7 | 2 OCC 1 P | | 22 6 43. | | 22 8 43. | 22 8 21. | | 22 10 44. | | 0.310 | 0.329 | 0.319 | 241 | 239 | 6.7 | 0.228 |
| 2009 12 8 | 2 OCC 3 P | | 11 31 46. | | 11 34 50. | 11 33 53. | | 11 37 54. | | 0.149 | 0.231 | 0.233 | 368 | 370 | 2.3 | 0.389 |
| 2009 12 10 | 1 OCC 2 T | | 4 31 54. | 4 34 8. | 4 34 12. | 4 34 6. | 4 34 16. | 4 36 30. | | 0.450 | 0.425 | 0.425 | 276 | 276 | 8.4 | 0.006 |
| 2009 12 11 | 2 OCC 1 P | | 11 17 3. | | 11 19 2. | 11 18 38. | | 11 21 2. | | 0.274 | 0.291 | 0.281 | 239 | 237 | 7.0 | 0.283 |
| 2009 12 13 | 3 OCC 2 P | | 0 49 43. | | 0 51 30. | 0 51 37. | | 0 53 17. | | 0.027 | 0.025 | 0.019 | 214 | 196 | 7.2 | 0.934 |
| 2009 12 13 | 1 OCC 2 P | | 17 43 8. | | 17 45 22. | 17 45 17. | | 17 47 36. | | 0.404 | 0.382 | 0.378 | 268 | 268 | 8.1 | 0.147 |
| 2009 12 15 | 2 OCC 1 P | | 0 27 43. | | 0 29 41. | 0 29 16. | | 0 31 38. | | 0.237 | 0.252 | 0.241 | 235 | 233 | 7.2 | 0.339 |
| 2009 12 15 | 2 OCC 3 P | | 15 1 27. | | 15 4 13. | 15 3 33. | | 15 6 58. | | 0.087 | 0.136 | 0.138 | 331 | 334 | 3.9 | 0.615 |
| 2009 12 17 | 1 OCC 2 P | | 6 54 25. | | 6 56 34. | 6 56 29. | | 6 58 42. | | 0.339 | 0.320 | 0.316 | 257 | 256 | 7.9 | 0.237 |
| 2009 12 18 | 2 OCC 1 P | | 13 38 46. | | 13 40 41. | 13 40 16. | | 13 42 36. | | 0.199 | 0.211 | 0.201 | 229 | 227 | 7.4 | 0.397 |
| 2009 12 20 | 1 OCC 2 P | | 20 5 55. | | 20 7 56. | 20 7 52. | | 20 9 57. | | 0.268 | 0.253 | 0.249 | 242 | 241 | 7.6 | 0.332 |
| 2009 12 22 | 2 OCC 1 P | | 2 50 9. | | 2 52 0. | 2 51 34. | | 2 53 51. | | 0.161 | 0.171 | 0.161 | 222 | 218 | 7.7 | 0.457 |
| 2009 12 22 | 2 OCC 3 P | | 18 34 47. | | 18 36 47. | 18 36 23. | | 18 38 46. | | 0.026 | 0.040 | 0.042 | 239 | 244 | 5.6 | 0.861 |
| 2009 12 24 | 1 OCC 2 P | | 9 17 30. | | 9 19 21. | 9 19 18. | | 9 21 12. | | 0.196 | 0.185 | 0.181 | 222 | 221 | 7.4 | 0.433 |
| 2009 12 25 | 2 OCC 1 P | | 16 1 57. | | 16 3 42. | 16 3 14. | | 16 5 28. | | 0.124 | 0.132 | 0.123 | 211 | 206 | 7.9 | 0.517 |
| 2009 12 27 | 1 OCC 2 P | | 22 29 15. | | 22 30 52. | 22 30 50. | | 22 32 30. | | 0.126 | 0.119 | 0.116 | 195 | 194 | 7.1 | 0.538 |
| 2009 12 29 | 2 OCC 1 P | | 5 14 3. | | 5 15 41. | 5 15 12. | | 5 17 19. | | 0.089 | 0.095 | 0.087 | 196 | 190 | 8.2 | 0.578 |
| 2009 12 31 | 1 OCC 2 P | | 11 41 8. | | 11 42 27. | 11 42 25. | | 11 43 46. | | 0.062 | 0.059 | 0.056 | 157 | 155 | 6.9 | 0.647 |
| 2010 1 1 | 2 OCC 1 P | | 18 26 36. | | 18 28 4. | 18 27 34. | | 18 29 32. | | 0.058 | 0.061 | 0.054 | 175 | 169 | 8.4 | 0.639 |
| 2010 1 4 | 1 OCC 2 P | | 0 53 19. | | 0 54 6. | 0 54 6. | | 0 54 53. | | 0.013 | 0.012 | 0.010 | 94 | 90 | 6.6 | 0.761 |
| 2010 1 5 | 2 OCC 1 P | | 7 39 27. | | 7 40 40. | 7 40 10. | | 7 41 54. | | 0.031 | 0.032 | 0.026 | 147 | 138 | 8.6 | 0.700 |
| 2010 1 8 | 2 OCC 1 P | | 20 52 52. | | 20 53 44. | 20 53 12. | | 20 54 36. | | 0.010 | 0.010 | 0.006 | 104 | 88 | 8.9 | 0.759 |
| 2010 3 17 | 2 OCC 1 P | | 22 39 30. | | 23 0 35. | 23 1 43. | | 23 25 2. | | 0.290 | 0.308 | 0.303 | 2733 | 2727 | 6.1 | 0.234 |
| 2010 3 21 | 2 OCC 1 P | | 9 51 53. | | 10 7 23. | 10 8 35. | | 10 23 21. | | 0.379 | 0.402 | 0.397 | 1888 | 1882 | 2.8 | 0.105 |
| 2010 3 21 | 2 ECL 1 P | 11 4 5. | 11 7 14. | | 11 24 47. | 11 26 43. | | 11 44 5. | 11 48 16. | 0.441 | 0.441 | 0.430 | 2212 | 2218 | 4.5 | 0.347 |
| 2010 3 24 | 2 OCC 1 P | | 21 21 2. | | 21 35 51. | 21 37 17. | | 21 50 39. | | 0.397 | 0.422 | 0.417 | 1777 | 1769 | 0.3 | 0.071 |
| 2010 3 24 | 2 ECL 1 P | 22 33 19. | 22 35 36. | | 22 49 53. | 22 51 24. | | 23 4 34. | 23 7 2. | 0.586 | 0.586 | 0.575 | 1739 | 1738 | 1.8 | 0.205 |
| 2010 3 28 | 2 OCC 1 P | | 8 42 23. | | 8 59 24. | 9 1 15. | | 9 15 41. | | 0.382 | 0.406 | 0.400 | 1998 | 1980 | 2.7 | 0.100 |
| 2010 3 28 | 2 ECL 1 P | 10 9 30. | 10 11 37. | | 10 25 12. | 10 26 37. | | 10 38 48. | 10 40 56. | 0.639 | 0.639 | 0.631 | 1632 | 1628 | 0.7 | 0.142 |
| 2010 3 31 | 2 OCC 1 P | | 16 53 25. | | 17 10 22. | 17 6 3. | | 17 32 44. | | 0.071 | 0.075 | 0.061 | 2359 | 2082 | 9.4 | 0.588 |
| 2010 3 31 | 2 OCC 1 P | | 19 19 58. | | 19 56 19. | 20 0 19. | | 20 22 39. | | 0.290 | 0.308 | 0.303 | 3761 | 3552 | 5.7 | 0.236 |
| 2010 3 31 | 2 ECL 1 P | 21 47 39. | 21 49 59. | | 22 4 26. | 22 5 59. | | 22 18 35. | 22 20 46. | 0.640 | 0.640 | 0.631 | 1716 | 1708 | 3.0 | 0.140 |
| 2010 4 4 | 2 ECL 1 | 4 36 3. | | | 4 42 46. | 4 41 36. | | | 4 49 42. | 0.009 | 0.009 | 0.005 | | | 11.0 | 0.947 |
| 2010 4 4 | 2 ECL 1 P | 9 8 22. | 9 11 23. | | 9 30 17. | 9 32 9. | | 9 47 33. | 9 50 20. | 0.582 | 0.582 | 0.570 | 2170 | 2147 | 5.5 | 0.208 |
| 2010 4 7 | 2 ECL 1 P | 19 6 27. | 19 19 15. | | 19 55 13. | 19 57 9. | | 20 28 1. | 20 38 37. | 0.135 | 0.135 | 0.166 | 4126 | 4658 | 9.0 | 0.679 |

**Table 11.** Visibility of the mutual events depending on the site of observation.

| Observatories | (1) | (2) |
|---|---|---|
| Sydney (Australia) | 70 | 131 |
| La Silla - ESO (Chile) | 68 | 138 |
| Itajuba (Brazil) | 66 | 134 |
| Capetown (South Africa) | 65 | 134 |
| Mauna Kea, Hawaii (USA) | 64 | 112 |
| Yunnan obs. (China) | 64 | 109 |
| Kavalur (India) | 60 | 115 |
| Monterrey (Mexico) | 67 | 111 |
| Canarian Islands (Spain) | 56 | 110 |
| Mt Wilson, California (USA) | 52 | 100 |
| Washington DC (USA) | 52 | 99 |
| Nanjing (China) | 51 | 99 |
| Dodaira (Japan) | 51 | 98 |
| Pico Veleta (Spain) | 49 | 98 |
| Beijing (China) | 49 | 90 |
| Pic du Midi (France) | 49 | 89 |
| Catania (Italy) | 46 | 94 |
| Rozhen obs. (Bulgaria) | 44 | 90 |
| Bucarest (Romania) | 44 | 88 |
| Barcelona (Spain) | 43 | 91 |
| Topeka, Kansas (USA) | 43 | 90 |
| Teramo (Italy) | 43 | 86 |
| Naucsny (Ukraine) | 42 | 81 |
| Bordeaux (France) | 41 | 86 |
| Haute Provence obs. (France) | 41 | 85 |
| Belgrade (Serbia) | 40 | 85 |
| Stuttgart (Germany) | 37 | 76 |
| Paris (France) | 37 | 76 |
| Uccle (Belgium) | 36 | 71 |
| Dresden (Germany) | 35 | 75 |
| Irkutsk (Russia) | 34 | 65 |
| Pulkovo (Russia) | 18 | 37 |

(1) All events, even grazing.
(2) Events easily observable: magnitude larger than 10 percent occurring at more than 1.5 jovian radius from the limb of the planet.

**Table 12.** Distribution of the events.

| Dates | | Number of events | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 2009 | Jan. | 3 | 0 | 0 | 3 | 0 | 2 | 1 | 18 |
| | Feb. | – | – | – | – | – | – | – | 5 |
| | Mar. | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 28 |
| | Apr. | 22 | 0 | 16 | 6 | 10 | 2 | 20 | 52 |
| | May | 45 | 0 | 41 | 4 | 28 | 9 | 36 | 76 |
| | Jun. | 56 | 1 | 45 | 10 | 27 | 32 | 24 | 103 |
| | Jul. | 53 | 0 | 52 | 1 | 25 | 40 | 13 | 132 |
| | Aug. | 77 | 1 | 42 | 34 | 47 | 49 | 28 | 163 |
| | Sep. | 58 | 2 | 46 | 10 | 26 | 27 | 31 | 164 |
| | Oct. | 48 | 1 | 46 | 1 | 18 | 13 | 35 | 133 |
| | Nov. | 39 | 0 | 34 | 5 | 22 | 2 | 37 | 103 |
| | Dec. | 23 | 0 | 23 | 0 | 13 | 0 | 23 | 75 |
| 2010 | Jan. | 4 | 0 | 4 | 0 | 0 | 0 | 4 | 50 |
| | Feb. | – | – | – | – | – | – | – | 25 |
| | Mar. | 10 | 0 | 0 | 10 | 9 | 4 | 6 | 3 |
| | Apr. | 3 | 0 | 0 | 3 | 1 | 3 | 0 | 20 |

(1) Total number of events.
(2) Number of events whose duration is less than 1 min.
(3) Number of events whose duration is more than 1 min and less than 10 min.
(4) Number of events whose duration is more than 10 min.
(5) Number of partial events whose magnitude of is more than 20 percent.
(6) Number of eclipses.
(7) Number of occultations.
(8) Mean distance Sun-Jupiter in degrees.

## 4. The observations of the mutual events

### 4.1. The receptors

The observation of the mutual events consists of the recording of the light flux as a function of time using a photometric receptor. At the present time, CCDs are the most common detectors used for this type of observation:

- the speed of the acquisition of the images allows the recording of at least 3 images per second (for short events);
- each image can be dated in UTC within an accuracy better than 0.1 s in order to obtain an astrometric accuracy of 1 kilometer for the relative position of the satellites.

Video cameras running at 25 frames per second may also be used, thanks to the brightness of the satellites. However, be sure to record the UTC time on each image. The advantage of two-dimensional receptors is the possibility of obtaining several satellites in the field. This will help for the photometric reduction, as we will see in the next section, The calibration.

Other types of detectors may be used, such as single channel photoelectric photometers for fast photometry in several spectral bands.

Photographic or visual observations should be avoided because of the poor photometric accuracy.

Any telescope, even small, may be used: the stability of the image and good guidance of the instrument is however necessary.

Technical notes on the use of several types of detectors are available by request from the author or on the web server of IMCCE at the address: `http://www.imcce.fr/phemu09`.

### 4.2. The calibration

Most of the time, the raw light-curves are difficult to analyse without a specific photometric reduction. Since we need only relative photometry (the recorded magnitude drop is measured referring to the magnitude of the satellites before and after the event). However, it is important to record a reference object not affected by the event at the same time. Using a two-dimensional receptor will allow the observer to simultaneously record the satellites involved in the event, and another satellite not involved, with constant brightness (at least during the event). Only for long events will it be useful to take into account the rotation of the satellites. A two-dimensional detector will also record the sky background simultaneously. The reduction will then easily solve the problems related to light clouds or to the variation of the elevation of the observed bodies in the sky, as well as to the brightness of the sky background before sunrise or after sunset. If using a single channel receptor, the observer will need to alternatively record the sky background and a reference object either during the event for a long event (more than 20 min) or just before and after the event for a short event.

### 4.3. The PHEMU09 campaign of observations

In order to optimize the observations and to catch the maximum number of phenomena, we organize a campaign of

observations for the coordination of the observing sites as we have done previously allowing publication of a very complete catalog of data such as in Arlot et al. (1997) for the 1991 occurrence and in Arlot et al. (2006) and Emelianov et al. (2000) for the 1997 occurrence and in Arlot et al. (2008) for the 2003 occurrence (the database is available at the address: `http://www.imcce.fr/fr/ephemerides/donnees/nsdc/nsdf/fjuphemu.html`. The reader is encouraged to join our campaign of observations, to contact the author at `arlot@imcce.fr` and to get information on the campaign of observations from the web address `http://www.imcce.fr/phemu09`.

## 5. The interest of the observations

### 5.1. Astrometry of the Galilean satellites

The goal of the observation of the mutual phenomena of the Galilean satellites of Jupiter is mainly to obtain astrometric data leading to relative positions of the satellites with high accuracy. Observations of the mutual events have been shown to be more accurate than photographic or CCD direct observations of astrometric positions. The measurement of the magnitude drop at the time of the minimum distance corresponds to the measurement of this minimum distance. Thanks to the absence of an atmosphere on the satellites, the observations are more interesting than those of the eclipses by Jupiter because of the sharpness of the light curves. In the past, observations of eclipses by Jupiter have led to relative positions determined within an accuracy of 1000 km, photographic or CCD positions within 500 km and mutual events within 100 km. This accuracy for the mutual events may be improved to 20 km or better using a more sophisticated reduction involving surface reflectivity.

Such observed positions help to fit the dynamical models of the motions of the satellites. Their accuracy allows a better determination of the eccentricities which should constrain the model of tidal effects on Io and Europe and the model of the interior of these satellites. Also, these observations allow detection of non-gravitational forces, especially for Io, through the determination of an acceleration in longitude. Space probes have made some precise observations over an interval of time too short to be able to determine an acceleration. For that, we need accurate observations over a long interval of time as provided by the mutual events. The first modern observations of these events started in 1973, providing us with more than thirty years of data necessary to measure an acceleration in the motion of the satellites.

### 5.2. Planetology: analysis of the surfaces

Looking for a better reduction of the mutual phenomena, Vasundhara et al. (1996) and Emelianov et al. (2000) demonstrated that a new reduction considering that the satellites are not uniform disks may help to improve the accuracy of the data. Surface effects were suspected to be non-negligible when observing the mutual events presenting light curves with an asymmetrical aspect. Taking into account the surface effects for the reduction allows the determination of unknowns related to planetologic parameters such as the porosity and the rugosity of the surfaces of the satellites themselves, implying different scattering laws affecting the observed light curves. Moreover, the observations in infrared wavelengths allow detection of volcanos and hot spots on the surface of the satellite Io, and measurement of their activity at the time of the observation (Descamps et al. 1992).

## 6. Conclusion

The occurrence of the mutual events in 2009–2010 is particularly favorable because of the opposition of Jupiter occurring when the mutual events are most numerous (i.e., at the time of the jovian equinox when the jovicentric declination of the Sun and the Earth is the smaller). The declination of Jupiter itself at the date of the events will be around −14 degrees, more favorable for observation from observatories in the southern hemisphere.

We encourage observers to make the most of observations during this occurrence in order to complete the collections of data gathered since 1973. Thirty-five years of such accurate data will allow a major improvement in the ephemerides of the Galilean satellites and in our knowledge of this dynamical system.

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## References

Arlot, J.-E. 1973, L'Astronomie, 87, 289
Arlot, J.-E. 1982, A&A, 107, 305
Arlot, J.-E., Ruatti, C., Thuillot, W., et al. 1997, A&AS, 125, 399
Arlot, J.-E., Thuillot, Ruatti, C., et al. 2006, A&A, 451, 733
Arlot, J. E. 1999, Proceedings of the 5th workshop PHEMU97, held in Catania, Italy on March 4-6, 1997, ed. Arlot J.-E., & Blanco C. (Paris: IMC Editions), 59
Arlot, J.-E., et al. 2008, The PHEMU03 catalogue of observations of the mutual phenomena of the Galilean satellites of Jupiter, in preparation
Descamps, P., Arlot, J.-E., Thuillot, W., et al. 1992, Icarus, 100, 235
N. V., Emelianov, Berejnoi, A. A., Vashkovjak, S. N., et al. 2000, A&AS, 141, 433
Lainey, V., & Tobie, G. 2005, Icarus, 179, 485
Lainey, V., Duriez, & L., Vienne 2006, A&A, 456, 783
Lainey, V., Arlot, J. E., Karatekin, O., & Van Hoolst, T. 2007, in preparation
Morrison, D., & Morrison, N. D. 1977, Photometry of the Galilean satellites, in Planetary satellites, (Tucson: University of Arizona Press), 363
Sampson, R. A. 1921, Mem. Royal Astron. Soc., 63, 1
Vasundhara, R., Arlot, J.-E., & Descamps P. 1996, Proceedings of the 172 IAU Symp., ed. S. Ferraz Mello, B. Morando, & J.-E. Arlot (Kluwer Acad. Pub.), 423