Worksheet: Estimating Planet Parameters

# Parameters of the Stellar Event

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Time of the peak of the event** | = | **t0** | = |  |
|  |  |  |  |  |
| Baseline magnitude | = | W149base | = |  |
| Change in magnitude (base to peak) | = | 𝛥mmax | = |  |
| Maximum magnification | = | Amax | = |  |
| **Impact parameter** | = | **u0** | = |  |
|  |  |  |  |  |
| Change in magnitude for A=1.34 | = | 𝛥m | = |  |
| Time at 𝛥m | = | t | = |  |
| **Einstein Timescale**  | **=** |  **tE = |t0 - t|** | **=** |  |

# Parameters of the Planet

**1. Where is the planet?**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time of the planet perturbation | = | tplanet | = |  |
| Time scaled to the Einstein timescale  | = | 𝜏 = |tplanet - t0|/tE | = |  |
| Source-lens separation | = | u = √(u02 + 𝜏2) | = |  |
| Position of the images | = | y± = ± (½) ( √(u2 + 4) ± u) | = |  |
| Is it a major or a minor image perturbation? |  |  |
| **Planet-star separation** | **=** | **s** | **=** |  |
|  |  | **log (s)** | **=** |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Angle between trajectory and binary axis** | = |  **𝛂** **= atan( u0 / 𝞃 )** | = |  |
|  |  |  |  |  |
| Duration of caustic entrance/exit | = | 𝛥t = 2t\* | = |  |
| **Source radius** | = | **𝛒 = t\*/tE** | = |  |

(See Appendix B for calculating the planet/star mass ratio)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Planet/star mass ratio** | = | **q** | = |  |
|  |  | **log (q)** | = |  |

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# Final Parameters

(in the order they will be used in the fitting)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| t0 | u0 | tE | 𝜌 | log (s) | log (q) | 𝛼 |
|  |  |  |  |  |  |  |

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# Appendix A: Other Useful Equations

(approx. assumes zero blending)

(approx assumes u<<1)

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# Appendix B: Calculating q

## Three Regimes:

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After calculating 𝝆, the procedure differs depending on the regime.

Regimes 1 (minor image) and 2 (major image), both with 𝝆 smaller than the caustic:

1. Based on whether this is a major image or a minor image perturbation, decide which planetary caustic structure you should use: diamond (major) or two triangles (minor).
2. Given 𝜶 and the features in the light curve, estimate the path of the the source through the caustic(s).
3. Estimate the duration of a caustic feature in the light curve.
4. Determine 𝝙𝝉 = 𝝙t / tE for that feature.
5. Use the diagrams and equations from Han (2006) to match 𝝙𝝉 to a caustic dimension, and solve for q. (Use the limiting approximations.)

Regime 3 where 𝝆 is larger than the caustic:

1. Determine the change in magnitude for the caustic, 𝝙magc.
2. Determine Ap from 𝝙magc.
3. Ap = 2q / 𝝆2 (Gould & Gaucherel 1997)

# Han 2006 ApJ 638, 1080: Major Image Caustic



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# Han 2006 ApJ 638, 1080: Minor Image Caustic







