PHY-765 SS19: Gravitational Lensing. Worksheet Week 6

1 Journal Club #1: Paper selection

Among the daily tasks of astrophysicists (of any scientist, really), is staying alert and on top of the current literature. As introduced in the week 1 worksheet the main ways of doing that in astronomy, is by regularly (daily or weekly) browsing astro-ph (or ADS). As it's easy to miss papers that might be interesting, and useful to discuss new results with co-workers, this regular browsing is often combined with journal clubs. There are many ways to structure a journal club, but common for most of them, is that quick introductions are given to a sub-sample of the current papers on a given topic selected by the people attending the journal club. A widely used tool in the community for organizing such journal clubs is VoxCharta. This exercise will try to mimic a lensing journal club.

1.1

Use astro-ph's search engine to get a list of papers posted or updated in the month of April 2019 with "lensing" in the abstract. Select the paper you find most interesting based on title or abstract and send it's URL in an email to kbschmidt@aip.de.

1.2

Read your selected pick and prepare a ∼3 minute overview of the paper (no slides). Obviously 3 minutes is not enough time to get into the glory details of the paper, so the overview should just answer the following questions:

- What is the title and who are the main authors of the paper?
- What is the aim of the work?
- What are the main conclusions of the work? Here you can show the main plot of the paper, if you think this is useful for clarification and getting the point across.
- What is your overall impression of the work? That is, do you see anything that could be improved? Is there (a lack of) clarity about the procedures used? What are the importance of the results seen in the broader picture? etc.

Hence, the overview is a 'teaser' (with spoilers) of the paper, making everyone aware of its existence, in case people want to follow up on it.

The paper overview will be given in class next week

2 The Shapiro time delay

The Shapiro time delay describes the delay of light caused by the photons passing through a gravitational field. Shapiro (1964) described how this could be measured by reflecting light off Venus as it's on the other side of the Sun wrt. Earth, forcing the light to travel through the gravitational potential of the Sun twice. This exercise presents the steps in predicting the Shapiro delay of such an experiment. We will use that the total travel time T from Earth to Venus is given by

$$\int_{-D_E}^{D_V} dz \left[1 + \frac{2GM_\odot}{rc^2}\right] = c \int_0^T dt$$

(Dividing the expression for dz in this week's slide 5 by $(1-2GM_\odot/rc^2)$, Taylor expanding and then integrating). Setting up the coordinate system as the illustration in this week's slide 5, with the integral along the z-direction and the Sun at $z = 0$ so that $r = \sqrt{z^2 + R_\odot^2}$, show that the Shapiro time delay is of the order 200μs.

3 Characteristic time delays for a point mass lens

Assume a point mass lens is at cosmological distance 1Gpc ($z_\mathrm{L} \sim 0.3$). Show that the time delays between two images of a background source, image θ_+ and θ_-, are of the order months to years if the lens mass is $10^{12} M_\odot$ or $10^{14} M_\odot$ under the assumption that $\beta = 0.1\,\theta_\mathrm{E}$ or $\beta = 2.0\,\theta_\mathrm{E}$ and that the geometrical time delay is insignificant.