Challenge#4: What are the most critical observables/measurables in LSB tidal features that will constrain theory?

Key products: Critical observables

Here are some thoughts: the lengths and geometry of stellar streams can constrain the accretion times (very roughly) for satellites. Johnston+ (2001) presents an estimate for both the satellite mass and accretion time assuming a ``great circle" orbit for the satellite. For example, the stream identified by Mouhcine+ (2010) around the famous NGC 891 with a width w=5 kpc at R(circ) = 26 kpc and a rotational velocity for NGC 891 of vcirc = 230 km/s (Fraternali+ 2010), and the angular extent of the stream of 4\pi. Combining these values with equations 11 and 12 of Johnston+ (2001), we obtain 2.4 x 10^9 Mo, and an accretion time of 1.5 Gyr. respectively. With VRO deep observations of every nearby galaxy in the Southern hemisphere, similar analyses can be done on every stream reliably detected. Critical observable: well-identified streams.

In the cases where the streams are not well resolved, a statistical comparison can be made with 3simulated halos for MW and lower mass haloes of disk galaxies. For example, there are now independent suites of MW-like haloes: see D'Souza+ (2018) and Elias+ (2020) using Illustris, and Font+ (2020) with the dedicated ARTEMIS simulation. Critical observables: mean and rms of halo light around galaxies.

People:
Sarah Brough
Nushkia Chamba
Pierre-Alain Duc
Gaspar Galaz
Enrica Iodice
Bryan Miller
Lee Spitler
Mireia Montes
Dan Prole
Sean McGee
Sugata Kaviraj
Garreth Martin
Fernando Buitrago
Chris Mihos
Chris Collins
Jeff Carlin
Facundo Gómez
Leader: Garreth Martin

Key Milestones with person/s responsible with Deadlines:

Kickoff meeting:

~~Please indicate availability here:~~
~~https://doodle.com/poll/n835x483ig6sc6na~~

Agenda:

- *Overall goal of this challenge*
- *Decide challenge leader*
- *Best time for subsequent meetings (alternate between US/Europe/Aus etc friendly times?)*
- *What theoretical predictions are possible/available?*
- *What observables can w`*

~~Topic: LSB working group challenge #4 kickoff~~
~~Time: May 6, 2020 7:00 AM Arizona (14:00 UTC)~~

~~Join Zoom Meeting~~
~~https://arizona.zoom.us/j/98821540546~~

~~Password: 474434~~

Summary of discussion:

Two approaches:

- A broad statistical study of a representative sample of galaxies.
    - Identification of presence of tidal features, irregular galaxies (could be achieved with citizen science or machine learning techniques).
    - Relatively non-parametric approaches like studying asymmetry of a given object as a function of surface brightness / image depth.

- A deep study of small numbers of objects in the local Universe, where we will be able to make detailed measurements of specific features and more precise classifications.
    - e.g. surface brightness, shape, mass fraction of tidal tails
    - Morphological classification of types of feature like shells, streams and tidal tails.
    - Possibility to use measurements of tidal tail shapes, merger timescales to test DM models.

Both approaches are useful, the first will be possible with initial data releases and deeper studies of nearby objects will become possible as data becomes deeper. Increasing depth will also allow statistical studies out to increasingly higher redshifts.

Challenges:

- Detecting individual tidal features.
- Achieving accurate enough photometry to measure the properties of individual tidal features.
- Classification of types of tidal feature and general detection of tidal features (machine learning or citizen science approach)
    - Sugata will contact GalaxyZoo regarding morphological classification of HyperSuprime-Cam survey, we may need citizen science in any case to produce training samples for machine learning

There was general agreement that we should try to alternate meetings between times that are better for Australia / America at least a few times to gauge how this will affect ability to attend. For Europeans we should be able to keep to reasonable hours.

Minutes:

Sugata Kaviraj:
Areas of interest - tidal features, stellar streams and, beyond the local Universe: broader morphological signatures (e.g. asymmetry). LSST depth / resolution will allow tidal features that are the result of mergers much further in the past to be detected. Can we isolate tidal features from the galaxy, measure properties e.g. surface brightness? Main challenge will be extracting this from the data. Can we use cosmological hydro sims to back-engineer mergers from their remnant (mass ratio, gas fraction, orbital parameters)?

Chris Mihos:
Should we restrict ourselves to LSST observables, or discuss also follow up?

Pierre-Alain Duc:
Shape, SB, colours already represent a significant amount of information and will be challenging on their own, so we should start here initially.

Sugata / Garreth Martin:
Agreement that followup that is enabled by LSST should fall under the remit.

Sean McGee:
Should we talk about predictions from different dark matter models which may produce different tidal stream features?

Chris Collins:
How exactly are we going to study tidal features?: Compare a statistical sample with simulations? different interaction stages? Fraction of total galaxy mass in tidal features? And how do we retrieve samples?

Pierre-Alain:
There is some existing work looking at the shape of tidal tails as a function of DM models (e.g. MOND). Generally idealised simulations of mergers. Tidal tails can help differentiate DM models.

Garreth:
Do we have anyone with the expertise to produce these predictions?

Sean:
People are starting to do work in this area, so would be possible to bring them in.

Pierre-Alain:
Merger timescales are also a potential test.

Sugata:
How do we actually extract the tidal features from LSST images considering the large data volume

Pierre-Alain:
For MATLAS we began with visual inspection to identify the type of feature (streams, shells, tidal tails). Annotation tools used to indicate position and extent of features over image (see here). So far unsuccessful with automated methods (machine learning) beyond simply detecting the presence of tidal features. Very complex to try to derive more detailed information in this way. There will be a trade off between size of sample and precision of the data depending on the techniques we choose.

Sugata:
We could choose a smaller field with a lot of complementary data and do visual inspection here. If we wanted to look at the full footprint, it could be possible to do similarity search for archetypes of certain tidal features using e.g. (Martin+2020).

Pierre-Alain:
In any case we will need to do some visual classification to produce training samples for machine learning. Can we convince the GalaxyZoo team?

Chris C:
Could we also use simulation directly to produce training sets?

Sugata:
Yes, but depends on the quality of mock images, which will depend on the mass and spatial resolution. e.g. if tidal features only carry a few per cent of the total stellar mass of a galaxy, we require very high mass resolution in order for those features to be present. Maybe it is better to start with a data-driven solution.

Sugata will ask Chris Lintott / Brooke Simmons at GalaxyZoo whether they will be willing to do the HSC-SSP as it is a good LSST precursor dataset.

Pierre-Alain:
Classification also depends on distance to objects… The precision of classification possible will differ, so we won't be able to do very precise classifications for distant objects (i.e. the majority of objects). Nearby objects will require more expert classifiers, so will not be a good fit for GalaxyZoo, but for the more distant objects a citizen science approach would work.

Garreth:
Will it be possible to go beyond statistical comparison of the frequency of different types of tidal feature? E.g. quantitative measurement of the length, brightness of tidal tails

Pierre-Alain:
It will be extremely challenging to do accurate photometry on individual features -- very large errors on magnitude.

Aaron Watkins:
This has a similar problem to measuring ICL. We have to define a way of measuring tidal features consistently.

Chris C:
Agrees. But tidal features are at least somewhat morphologically distinct from the rest of the galaxy. Should we be looking deeper at objects that we know to have tidal features or attempt to obtain large representative samples?

Sugata:
Greater depth will allow us to see tidal features from lower mass ratio mergers or pick up other tidal features more easily, so they are interlinked.

Pierre-Alain:
Greater depth also allows us to see the remnants from older tidal features (i.e. mergers that happened earlier in the history of the galaxy).

Chris M:
A more tractable way of looking at large samples would be to look at e.g. asymmetry of an object as a function of surface brightness. Can then follow up on these objects later to do more comprehensive analysis.

Garreth:
Agrees. Also with a morphological classification we will also have to find a way to do the same classification on simulated objects

Greater depth will allow us to see tidal features from lower mass ratio mergers or pick up other tidal features more easily, so they are interlinked. Pierre-Alain (asked to describe the annotation tools used for MATLAS):
Uses a similar platform to GalaxyZoo with an additional layer allowing annotation over the image. GalaxyZoo only has static images, MATLAS platform allows much greater control over visualisation of the image (using Aladdin), which is important when looking at low surface-brightness features.

Aaron:
On the broad vs deep approach: With only a few objects we learn little about the Universe and only about these objects, so it would make more sense to start with a large representative sample.

Pierre-Alain:
The nature of the survey means we will have to start broad anyway, as initial data will be relatively shallow, eventually data will become more informative, including large samples of nearby, well resolved objects.

Aaron:
Agrees. Deep imaging of nearby objects will be most useful for uncovering surprises, which we would not see in a large statistical sample. Makes most sense to graduate to this approach following a statistical study using the early data releases.

Sugata:
Initial data will be equivalent to Stripe82 depth over 20,000 sq. degrees. There will be a lot of science possible in the low redshift ($z < 0.2$). As depth increases, this will allow us to probe to deeper redshifts -- allowing us to explore the time evolution of e.g. merger rate.

Pierre-Alain:
Perhaps more important than depth will be the background subtraction.

Chris C:
Would LSST outreach be able to help create a citizen science effort (search for tidal features)?

Sugata:
Should approach GalaxyZoo as LSST may not have the resources/remit to do something like this.

Garreth:
We should also think about injection mock images for classification alongside real ones or we can't do any comparison.

Sugata:
Eagle,Illustris have already been processed through GalaxyZoo, so it is possible. But they will need to be convinced that it will be worthwhile.

Pierre-Alain:
For LSST, there will need to be some high-level agreement r.e. access to the data and the platform. We would have to make sure that LSST data rights are compatible with something like this.

Sugata:
LSST will not release images to anybody without data rights, so this will have to be negotiated directly between the LSST corp and GalaxyZoo on behalf of all data access holders. LSST should be happy to do this, may have to convince GalaxyZoo it is worthwhile (e.g. expected publications). Science collaboration can offer to aid in negotiating.

Fernando Buitrago:
Will it be possible to do some rough SED fitting on tidal features using the 6 photometric bands. e.g. to quantify the stellar mass within tidal features. Can we push LSST to provide tools for photometric fitting on a pixel by pixel basis?

Sugata:
LSST will not be doing any kind of high level analysis like SED fitting, but images would be available to do your own fitting.

Garreth:
Will photometry be good enough to do this for tidal features?

Pierre-Alain:
It should be possible for a limited sample of galaxies but it would be extremely challenging to do this for a large sample.

Meeting #2

~~Please indicate availability here.~~

~~https://doodle.com/poll/wnwauvevzxt8u26z~~

Topic: LSST LSB working group challenge #4: 2nd meeting
Time: May 28, 2020 09:00 AM Universal Time UTC

Join Zoom Meeting
https://arizona.zoom.us/j/92945916753

Password: 310740

Outline of challenge goals:

1. Initial simple study of tidal features with statistical comparison to theoretical results.
2. A full morphological comparison exploring the frequency of different types of tidal features present in observed and theoretical data.
3. Detailed study of the properties of individual tidal features including e.g. the mass fraction contained within tidal features and possible investigation of shapes in context of comparing DM models.

Agenda:

- Allocate tasks
    - Basic measurements using HSC-SSP data (e.g. asymmetry of an object as a function of surface brightness as Chris M suggested)
    - Producing / procuring mock observations to perform the same measurements on. (We may want to use multiple simulations to compare) - Jackson/Martin/Kaviraj (Horizon-AGN and New Horizon)
        - Initially try with mock images (raw and LSST-like noise etc)?
    - Explore the viability of measurement of tidal feature properties for nearby objects (e.g. photometry, SED fitting). Mireia - Enrica - Marilena
        - Do we need to put mock images through the LSST detection algorithm somehow to do this?
    - Approach Galaxy Zoo r.e. classifying HSC data (and whether we could also inject mock galaxies to be classified alongside HSC images. - Sugata (in progress)
- Schedule and milestones

SB taking minutes:

SK regarding approaching galaxy zoo: talking to Brooke & chase up with her. Could also look & tag mergers?

Tasks:

1. Amplitude of tidal features in an object. Could then be matched to mock observations. Look at different SB limits and examine asymmetry measured at different limits.

Can assume they will be detected as likely bright galaxies. But how will background subtraction affect?

CAS asymmetry measure as way of detection ?

Take known examples/catalogue of tidal galaxies and work out how detected in HSC?

Insert examples into reduced data and test detection.

Need to work out what can effectively measure in observations. For galaxy at distance X, how well can we measure: brightness/ SED fits/ shape / colour? Need to work out what the ideal objects are that testing.

Sean McGee can also do from EAGLE (SPH code); as well as Garreth etc. efforts with HORIZON-AGN (grid code).
w
Ask for pixels > 3Re

Need to worry about whether features are a result of interaction with surrounding medium (hydrodynamic) or other galaxies.

Catalogue of objects from HSC DR2. Get postage stamps? Get classifying!

Next meeting in ~3ish weeks.

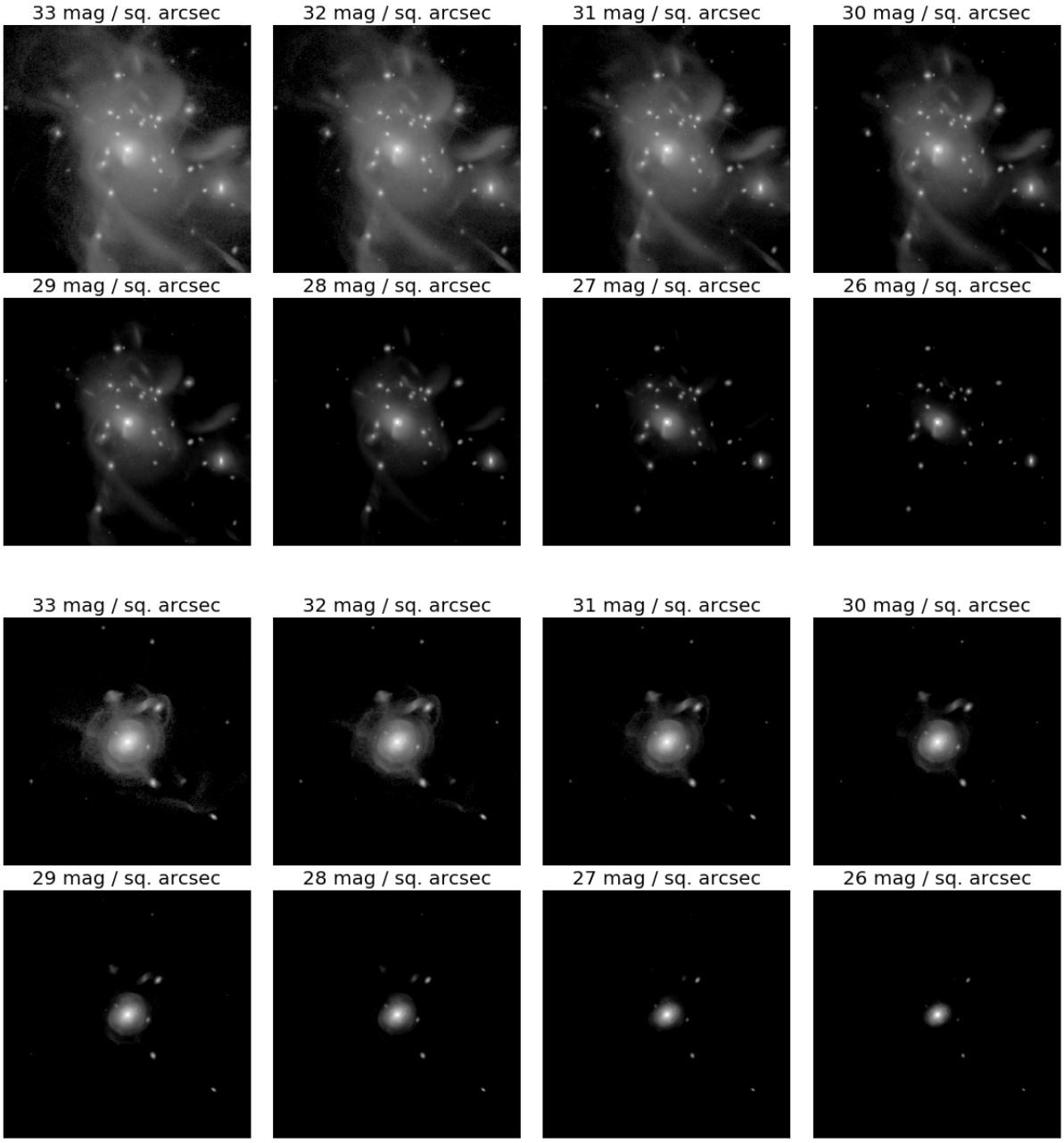
02:14:23 From Aaron Watkins : Was thinking about asymmetry measurements, and I remembered this one from Chris Conselice:
https://iopscience.iop.org/article/10.1086/308300/fulltext/
Might be useful.
02:17:57 From Mireia Montes : Have you talked about these one? Tidal Features at 0.05 < z < 0.45 in the Hyper Suprime-Cam Subaru Strategic Program: Properties and Formation Channels

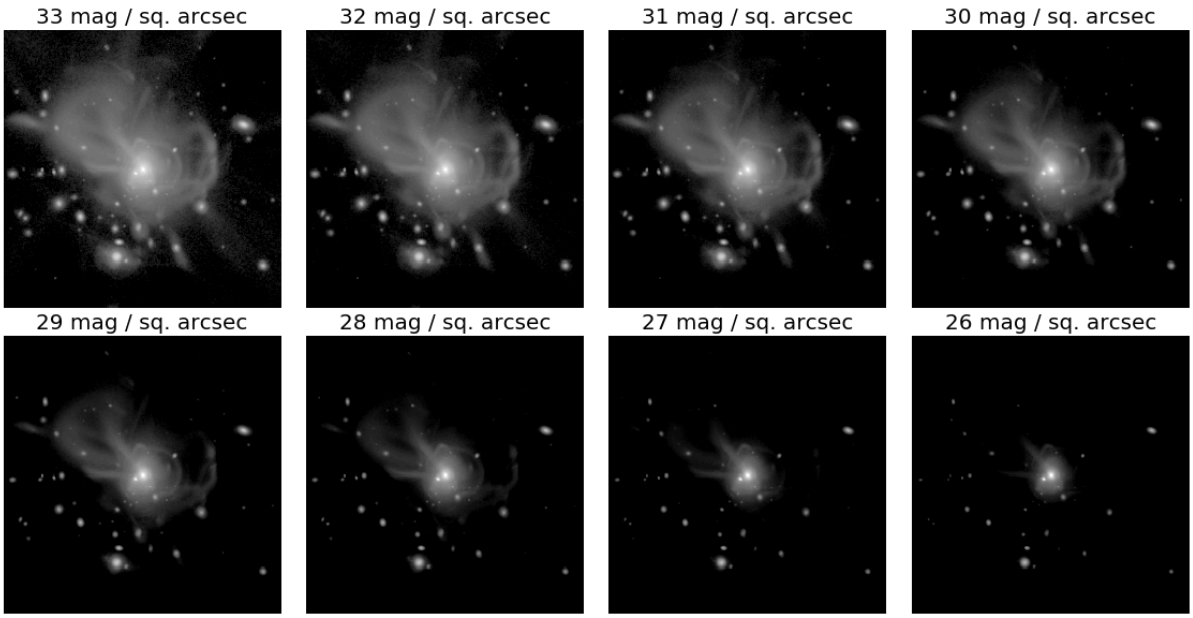
Meeting #3

Agenda:

- Enrica will discuss her experience with VST deep imaging
- Discuss https://www.zooniverse.org/projects/sundial-itn/space-fluff and possibly incorporating HSC data

Mock image examples (NewHorizon simulation):





List of papers:

Johnston et al. 2002: INTERPRETING THE MORPHOLOGY OF DIFFUSE LIGHT AROUND SATELLITE GALAXIES Kathryn V. Johnston and Philip I. Choi and Puragra Guhath

Choi et al. 2002: TIDAL INTERACTION OF M32 AND NGC 205 WITH M31: SURFACE PHOTOMETRY AND NUMERICAL SIMULATIONS1 Philip I. Choi and Puragra Guhathak

Bilek et al. 2020 (visual inspection): Census and classification of low-surface-brightness structures in nearby early-type galaxies from the MATLAS survey

Kado-Fong et al. 2018: Tidal Features at 0.05 < z < 0.45 in the Hyper Suprime-Cam Subaru Strategic Program: Properties and Formation Channels

Notes, Meeting 24/9/20 (SB)

Garreth: Mocks images on slack, from Horizon AGN. Limited subset of images. Parameter space: range of mass ratios & time elapsed since merger. Also interested in flybys too.

SB interested in where a particular observed tidal feature comes from.

Chris Mihos: To make tractable: Amount of material at some surface brightness, within some isophote? Least amount of human definition.

Chris Collins: What is the fate of the material?

Images need to be matched to LSST depths. Only able to be done at low-z. Should produce images at 0.05<z<0.2? Idealized images? Could we go to z~0.5? Incorporate angular size - to consider background issues? No, ignore background issues for now as will be solved separately. Consider PSF? No, should not be a substantial effect so ignore for now.

Add postage stamp mocks to real images to get real noise, not just add Gaussian noise.

Pick out 1 - a few objects that are easiest and add them into HSC co-adds, convolve mock images with PSF.

What do people want to do / contribute?

- Useful to back engineer properties of merger from properties of tidal feature. Mass ratio. Gas ratio. Time since last merger. Mass ratio & time likely degenerate. Mock images can show how degenerate that is, as a function of SB of tidal feature. Bunch of mergers with different mass ratios, and range of images after merger. Do flybys contribute false-positives? Should take colour of feature into account? Benne: (From Johnson +08) Minor mergers one can use the length of the arc, which maps the age of the interaction 1pi = 1 Gyr. Might be worth exploring colors involving the most extreme bands (i.e., ug, zy) in simulations to see if there's discriminatory power there.
- Real targets or

Garreth, Ryan & Sugata downloaded all 44,000 HSC Deep galaxies >10^8 labelling features, finding tidal features by eye. Tidal features visible down to 10^8.

Number of arcs give you age?

Take sims and try and reproduce what eyes are doing? Ask sims: Beyond time, Beyond some radius, how much light is there? Also consider colour and asymmetry of that light.

Who Can Do What: Bring all LSB people together each Challenge leader to give short summary. See where people are interested in contributing.

Garreth to produce some mock images as discussed.

Enrica: I would like to work soon on the mock images. In particular, following Chris' suggestion, we can derive the amount of accreted mass and ICL by studying the azimuthally averaged SB profiles, as done on real images. These quantities can be directly related to the predictions, i.e.

accreted mass vs total stellar mass. The tidal features results as "high-frequency structures" on the diffuse material produced by the accretion and merging processes.
In details:

- we can map the average surface brightness profiles to set the scale of the different components (in-situ vs ex-situ) and to estimate the total accreted mass. This quantity can be related with the total stellar mass of the galaxy (as done in several works Spavone et al. 2017, 2018, 2020; Iodice et al. 2020, 2019)
- we can estimate the total amount of ICL, defined as the combination of the light in the stellar envelope plus the diffuse light in the intracluster space;
- as showed in several theoretical papers (e.g.Deason et al. 2013, but also recent ones from Cooper or Illustris team), the shape of the SB profiles provides a strong indication on the type of mergers, I mean major vs minor mergers. For instance, shallower profiles are indicative of ongoing accretion of low-mass satellites

When available, the color maps and integrated colors of tidal features can be used to address the formation of stellar envelope.

One additional suggestion: convolving the mock images with the LSST simulated PSF would help to study how the outer wings of the PSF affect the SB profile at large radii. This is an important step to study the galaxy outskirts and to estimate the ICL contribution.

Meeting for Nov 24 2020

Join Zoom Meeting
https://arizona.zoom.us/j/81884825179
Password: 498511

Agenda:

- Hear summaries people who plan to help out with the study (Enrica / Marilena & Amir have volunteered so far)
- Marilena and Enrica will present preliminary results
- Any other ideas or volunteers
- Discuss how we want to define tidal features for the purposes of measuring their detectability
- Discuss the structure of the paper -- rough outline here: (https://www.overleaf.com/project/5fb1bb336f8c39035446995e)

Marilena:

- Analyse the tidal features in the mock images from Garreth to derive estimates for accreted mass vs redshift and colours of the features

- Tails appear to be redder than the parent galaxies which may not fit with predictions from simulations?

Amir:

- Developing a method to quantify S/N of streams around galaxies as a function of the mass and spatial resolution of the simulation

Garreth:

- For different SB limits the actual detectability of tidal features
- Need to come up with a definition of what a detectable tidal features is

Link to paper overleaf: https://www.overleaf.com/project/5fb1bb336f8c39035446995e

HSC PSF guy: Roberto Baena rbaena@iac.es (should be part of the challenge, MM)

Meeting for Jan 27 2021

Join Zoom Meeting
https://arizona.zoom.us/j/88670304010
Password: 763940

Agenda:

- Progress with the paper so far (https://www.overleaf.com/4979232639yfdqsrcgjndh)
- Colour profiles
- Testing accretion history

Attending: Garreth Martin, Sarah Brough, Pierre-Alain Duc, Mireia Montes, Gaspar Galaz, Sugata Kaviraj, Enrichetta Iodice, Jeff Carlin, Matthew Thorne, Chris Collins, Chris Mihos, Maria Angela Raj, Ricardo DeMarco, David O'Ryan, Aaron Watkins, Brandon Kelly.

Garreth presenting the draft paper with simulated tidal features in, which incorporate dust. Question regarding extent - images shown are infinite extent. Plots of tidal feature flux vs stellar mass of galaxy. Look at recovered flux vs stellar mass vs redshift vs surface brightness limits. By surface brightness mu_r < 29 struggle to study any tidal features above nearest, highest mass galaxies.
Enrichetta - can add bits on measurement technique to the draft.
Chris C - density as a measure of the emission contrast?
Chris M - density cut made? Made at limit by-Garreth's-eye to try and keep in theoretical

space. How make those more physically-motivated? Look at simulated images of stream-particles only and ask what is the SB where we stop seeing any stream particles.
Sugata - interested in knowing what merger mass ratios can be found at given z and SB limit.
Enrichetta can talk about recovering ex-situ/total-accreted fractions using observed method (clear prediction of ex-situ fraction from simulation). But can't tell what caused merger. This paper is focussing on determining confidence in how much we can recover observationally.
Chris M - Can we distinguish galaxies with high accretion / low accretion over last Gyr?
Sarah - can we bring in colour too to distinguish events? Pierre-Alain - colours are hard, much easier to measure shape than colour.
Garreth - time frame over which tidal features persist?
Concern that these are too much for this paper. Keep this one as, what can we observe and how compare to simulations. Another paper would be if you see this you've seen this kind of paper - and would need larger sample for full breakdown.
Chris M. - pointing out that while ex-situ is predicted, it should be mentioned that the viewing angle will have an effect. Maybe analyse a single object viewed from several different orientations and ask what is the dispersion in derived parameters
Enrica - a paragraph on what did generate those features in the simulations. And use colour to give constraints.
Chris C - want this to be cookbook for observers, how do observers analyse the data, to get constraint on models.
Mireia - use challenge group for farming out visual identifications (or other work). Garreth - might need to be to different SB limits.
Pierre-Alain - discussing work on comparing tidal features to simulations.
https://ui.adsabs.harvard.edu/abs/2019A%26A...632A.122M/abstract
Garreth to send out shortly connection details for paper as well as for people to list observables shortly. Next meeting in ~2 months.

Meeting for Mar 29 2021

Agenda:
Plans for visual classification of the tidal features in mock images.
A few things to consider before we meet:
(1) Mock images for classification - I think the best way to do this is to try and produce a flat image with multiple useful scalings so it is not necessary to manually stretch the images in DS9 - this is my current prototype - https://www.dropbox.com/s/x7j85pt90nk8n7w/test_classification.png?dl=0 each quadrant is for a different binning from 0.2"x0.2" to 10"x10" and for each panel within each quadrant I plot the SB map with an increasing maximum SB [25, 28, 31 mag / sq. arcsec], the final image in each quadrant is an arcsinh stretched g,r,i false colour image.
(2) Range of parameters - We should produce the images for multiple redshifts, projections and limiting SBs to gauge how these effect our ability to recover tidal features.

I think it is best to classify the images for a range of limiting surface brightness (say 28 to 31 mag / sq. arcsec), rather than target a specific prediction. This way we don't have to worry about these values being wrong + we can make predictions for e.g. 1 year and 5 year as well as 10 year depth. The range of parameters we can target will depend on how many people would like to volunteer to help.
(3) Classification criteria - I have prepared a spreadsheet using relevant criteria from Bílek, Duc et al. 2020 (https://arxiv.org/pdf/2007.13772.pdf) - https://docs.google.com/spreadsheets/d/1M0ktt7PxBMKw5syKeN87AOeC87cZcpyWlxk_qVVS6FM/edit?usp=sharing - maybe there are other criteria (e.g. plumes) that we should also consider or perhaps we should consider more detailed classifications. I think we should try to gather some examples of each category of LSB feature from the mock images so that everyone is on the same page.

Sorry, I forgot to take notes, but I will summarise the main points of discussion below:

Images: we should decide on the most effective binning of the images (e.g. the original 0.2”X0.2” or 2”X2”) the binning that is most effective will probably depend on redshift though (use fixed physical scale instead of fixed angular scale?).

Parameters:

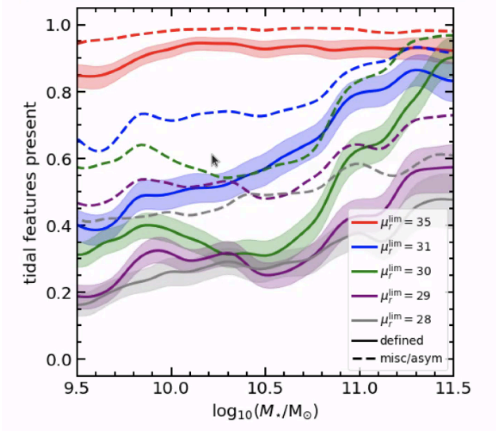
- redshift: minimum 0.05, maximum 0.8
    - (0.05, 0.1, 0.2, 0.4, 0.8) - we lose all of the extended tidal features by z=0.4, but worth considering higher redshift for identifying mergers
- Projections (xy, yz, xz)
    - I think we agree this is fine
- SB limit (28 mag arcsec^-2 to 31)
    - Want to capture ~single exposure limiting mag up to 10 year depth
    - I think we all agree this is ok too
- We want to consider how the pixels in the image are binned as we may only have access to one pixel binning in a bespoke LSB pipeline
    - It would be useful if we can recommend a binning
    - If possible we should decide on a single binning beforehand and use that for the images
        - Not clear if redshift will strongly affect this
        - Or if the scale of the tidal features is important

Classifcations:

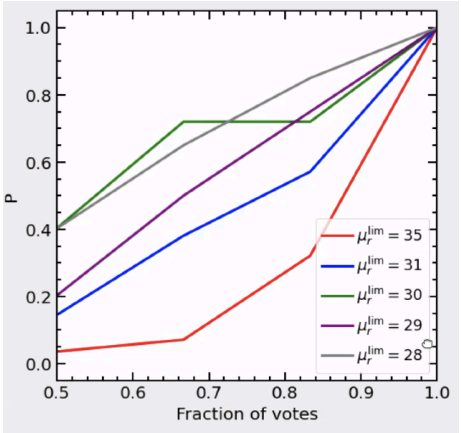
- Do we want to only identify general features (e.g. mergers / non-merger) or do finer classifications (e.g. number of streams, tails, presence of loops, asymmetry in outer isophotes
    - We should do detailed classifications, but granularity that we can classify objects at will probably change as a function of redshift
    - Maybe we should have separate classifications for objects with high redshift
- We should prepare some example classifications based in the categories in https://docs.google.com/spreadsheets/d/1M0ktt7PxBMKw5syKeN87AOeC87cZcpyWlxk_qVVS6FM/edit?usp=sharing

Meeting for June 23 2021

- Helpful suggestion to comment on classifications from Chris.
- Feedback collated: People not super confident that if they repeated their classifications they wouldn't necessarily choose the same classification again. Would identify presence of tidal feature but exact identification might change.
- Can test comment that people found first few harder as they settled into classification.
- How many people classified a specific image. 6 people classified 900 galaxies to work out concurrence. For remaining thousands of galaxies had 2 votes.
- Faintest limiting SB went to 35 mag arcsec
- **Still waiting on some classifications => get on with it people :)**
- Plot of fraction of tidal features present vs stellar mass for different limiting SB depths:



- If trying to use tidal features to determine whether merger taken place have to be careful as in deepest images EVERYTHING has feature.
- P-A D: That is telling us something about the properties of those galaxies
- Plot of concurrence of identifying presence of any features between classifiers (for 900 galaxies classified by 6 people). People more likely to identify whether feature or not at lowest SB limits.

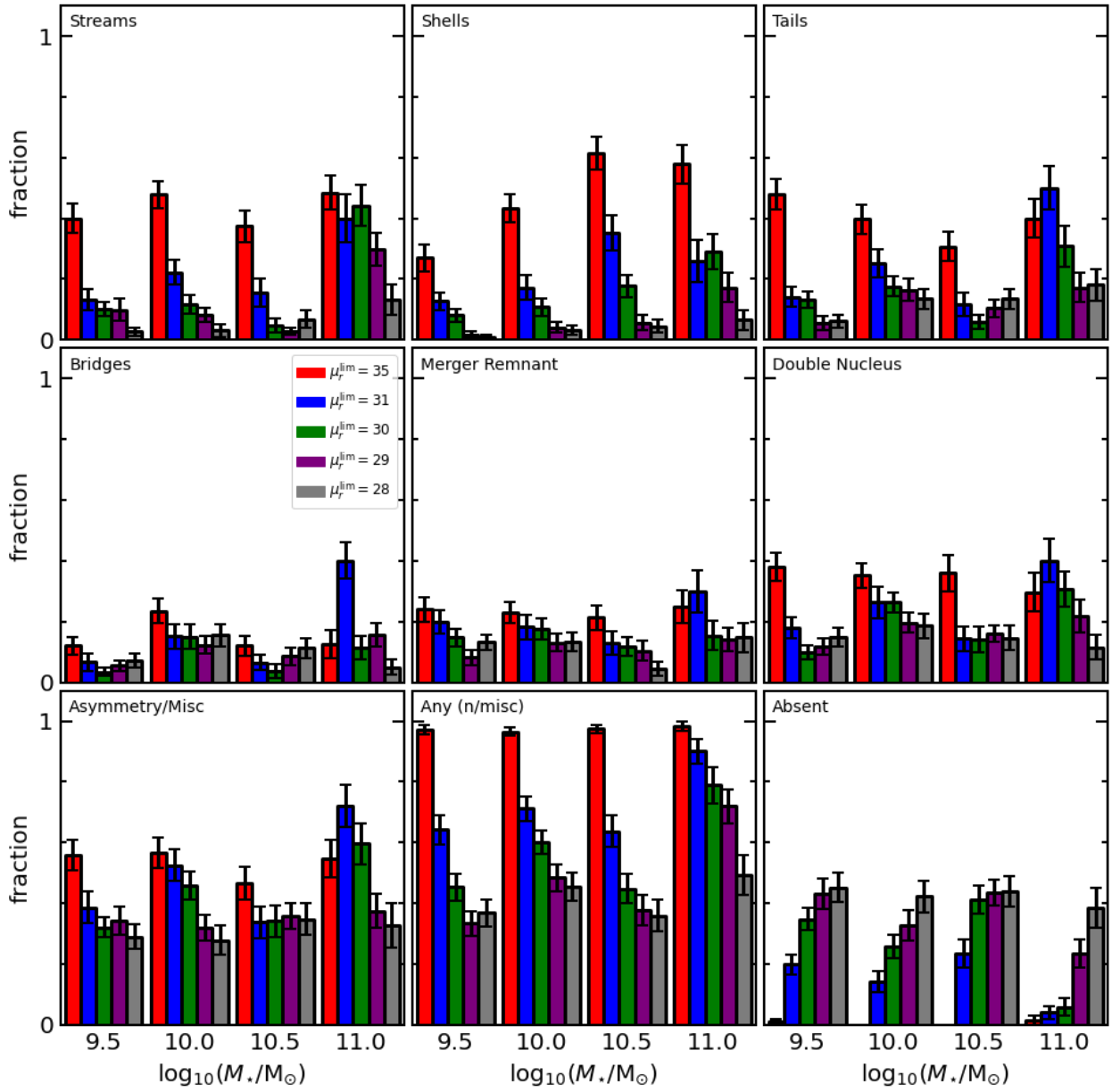


-
- How test the strength different biases produce (e.g. viewing inclination)??? Votes have are based on number of features. How well can people in same postage stamp count # features? Within 900 set of galaxies that are classified 6 times there are a few galaxies viewed at different inclinations but possibly not enough to answer the

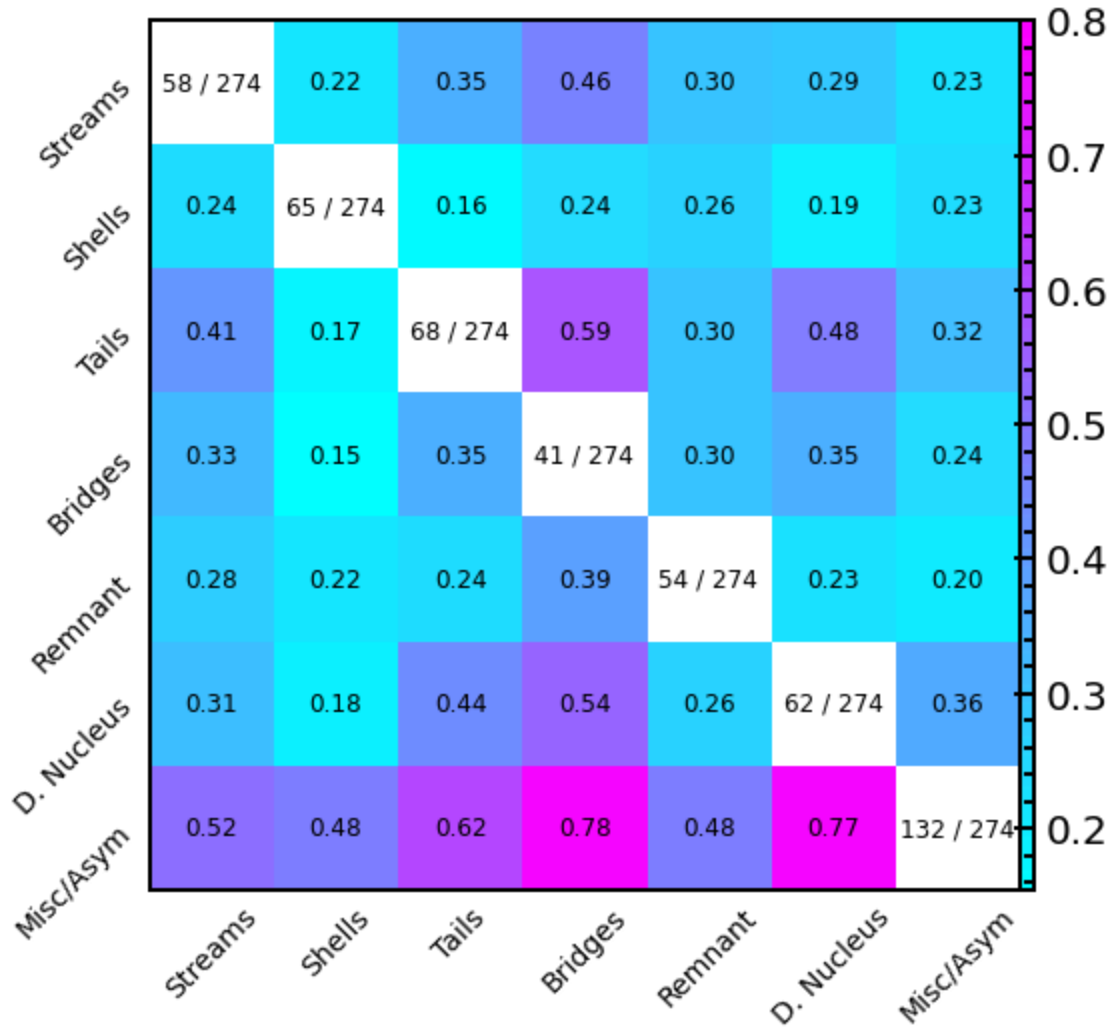
question of how inclination affects results.

- Uncertainties are: random error within classifier. Definition identifier between classifiers. Intrinsic differences in systems.
- Discussion in paper re how difficult this is
- Do we have “ground truth” from simulation? Similarly tricky to visual classification… not sure that will be possible to disentangle in every case what produces these features. Can look at busy / quiet merger history and in-situ/ex-situ stars.

Some more preliminary plots - Not all the data is processed yet, so plots may change.



Fraction of galaxies at different masses and limiting SBs that display given features



Correlation between coincident classifications