Merger Tutorial

April 17, 2008

1 Finding Robust Mergers

This document is designed to help users of Galaxy Zoo make informed decisions about what to register as a merger. Figure 1 shows the distribution of merger votes as of January 2008. As you can see, a *very* small number of mergers make it into our most reliable categories (hatched on figure) from which we get our data. That means we are currently missing out on a great number of merging galaxies that would make an invaluable contribution to cutting edge research. By laying out some guide lines to help users better identify a merger, the Galaxy Zoo community will be able to obtain more data which is important in doing good science. You can help us by looking through some of the example figures and taking note of some of the pit-falls users fall into when trying to find mergers.

Remember, this is just a guide line! The user's judgement is unavoidable and, desirable (otherwise we'd be using a computer to do this). Don't worry about making mistakes - you make far fewer than a computer would.

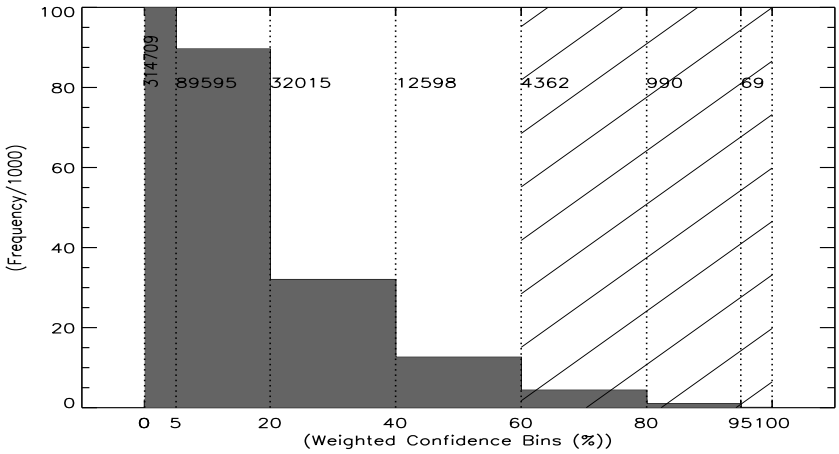

Figure 1: The distribution of weighted merger votes. The shaded area represents categories from which we have created our initial catalogue of robust, binary mergers. We are interested in further extracting mergers from the 40-60% bin.

2 What We Are Looking For

A working definition of a merger: **"Anything that has a disturbed morphology and is the product of two or more galaxies."** In particular, we are looking for binary mergers,

but be sure to flag anything that looks like its a multi-merger (i.e. involving three or more galaxies).

3 Merger Misclassifications

The most common pit-falls for misclassifications are the following:

- **Insufficient disturbance:** this is clearly a very difficult factor to demarcate. Often a galaxy will show signs of very minor perturbation (possibly a post-merger[1] or a minor merger[2] with a dwarf galaxy). Our general advice is to select something as a merger if the *core* of the suspected low-mass galaxy is still visible. If the cores are completely blended and there are no extra patches of over-densities, then mark it as an elliptical or spiral.
- **Stellar overlap:** sometimes a star lies over or near the galaxy image. Stars are characterized by a bright, highly uniform colour that show little to no sign of morphological 'disturbance.' The galaxy almost always looks unperturbed as a result. Sometimes a star might overlap what looks like a possible merger. Usually we want to avoid these since the star will interfere with our analysis. See Figure 2 and 3 for examples.
- **Galactic overlap:** similarly, sometimes two galaxies look as though they are merging in virtue of a close galaxy lying in the same line of sight as a more distant galaxy. They can usually be distinguished by a lack of disturbance, i.e. if they were interacting then they should show signs of shape disruption.

1	2	3	4
5	6	7	8
9	10	11	12

Table 1: Label positions for images in figures 2-6.

[1] A galaxy which has undergone a merger and is on its way to being or is completely settled

[2] A merger between two galaxies where one is much larger than the other

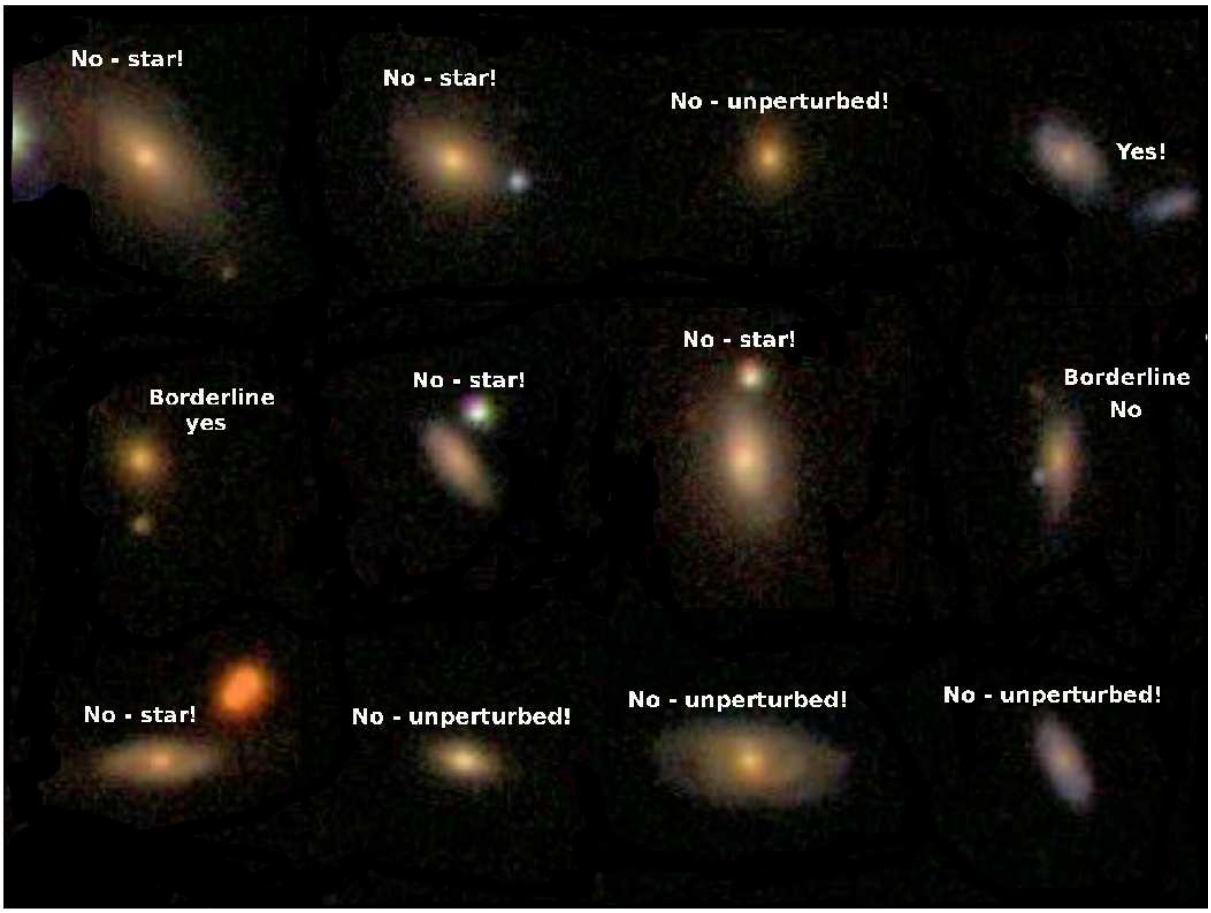

Figure 2: Example images from the 0-5% group. Comments: one can see that (2) is a star by a lack of blending and the stark/sudden contrast in colours. (4) probably is a merger (not, say, projection of two disparate galaxies) as indicated by the pulling of the tidal tails towards each other. (8) looks like it has a small star over it (blue dot at 8 o'clock) plus the disturbance at the top shows no sign of a core, hence a reject though possibly a very minor merger.

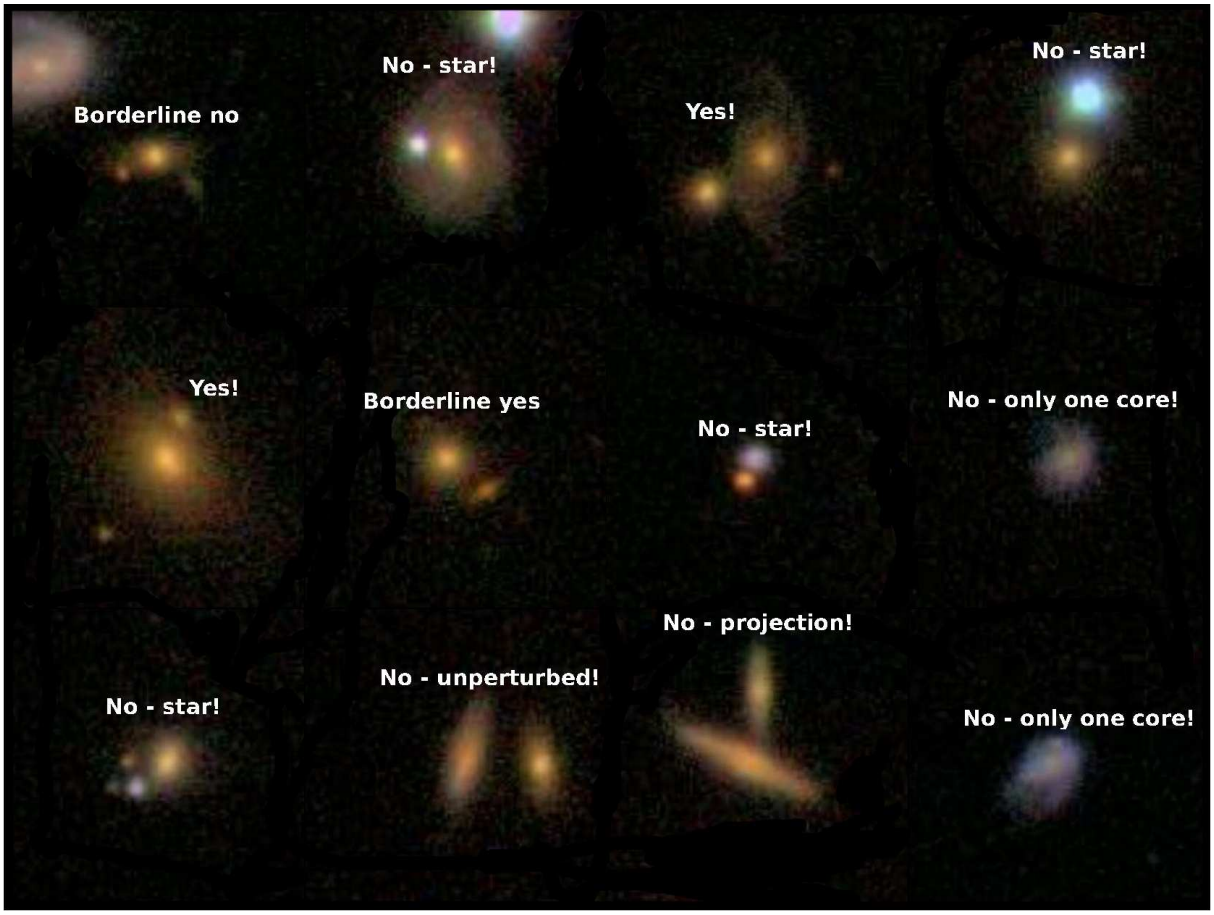

Figure 3: Example images from the 5-20% group. Comments: (1) firstly, the elliptical is almost certainly nowhere near the spiral to the top-left since ellipticals tend to be much more massive. There appears to be a faint star over the left side of the elliptical though difficult to tell. The disturbance to the bottom right is certainly a legitimate sign of merging though shows no sign of a core and so should be rejected. (3) shows slight sings of blending between these two galaxies and so is unlikely to be a projection. (5) is a definite yes - the core of the less massive galaxy is clearly visible and should be picked up by SDSS as a distinct object. (6) Although it is possible that the smaller looking galaxy is more distant (i.e. we have a projection) there is a good chance that it is a good merger and should be included. (9) looks like a possible merger but has a star over it on the left and so should be rejected. (10) and (11) show little sign of disturbance and so are unlikely to be the same distance away from us (i.e. projection). (12) shows clear signs of disturbance but no double core.

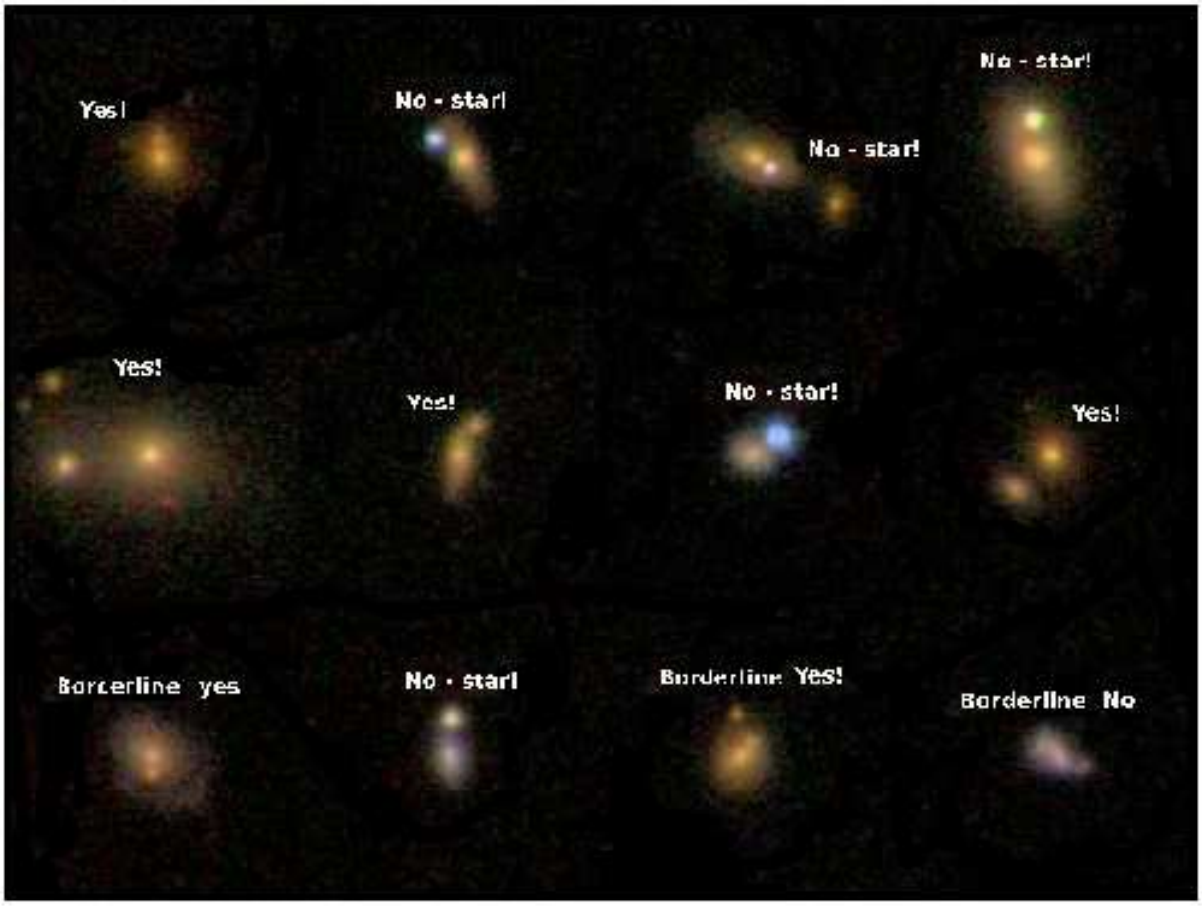

Figure 4: Example images from the 20-40% group. Comments: (3) this would be a good merger except that the star near the merging core might interfere. (4) is especially difficult - on the one hand the 'core' near the top looks a star since it is so bright and contrasted with the surrounding matter. On the other hand, the shape of the galaxy seems to fit around it. I would choose no here because we defiantely DON'T want stars in our sample!!! (11) has a small merger near the top which is just about enough to get picked up by SDSS as a separate photometric object. (12) shows marginally insufficient signs of a second core to rank as a robust merger and is probably a post-merger object.

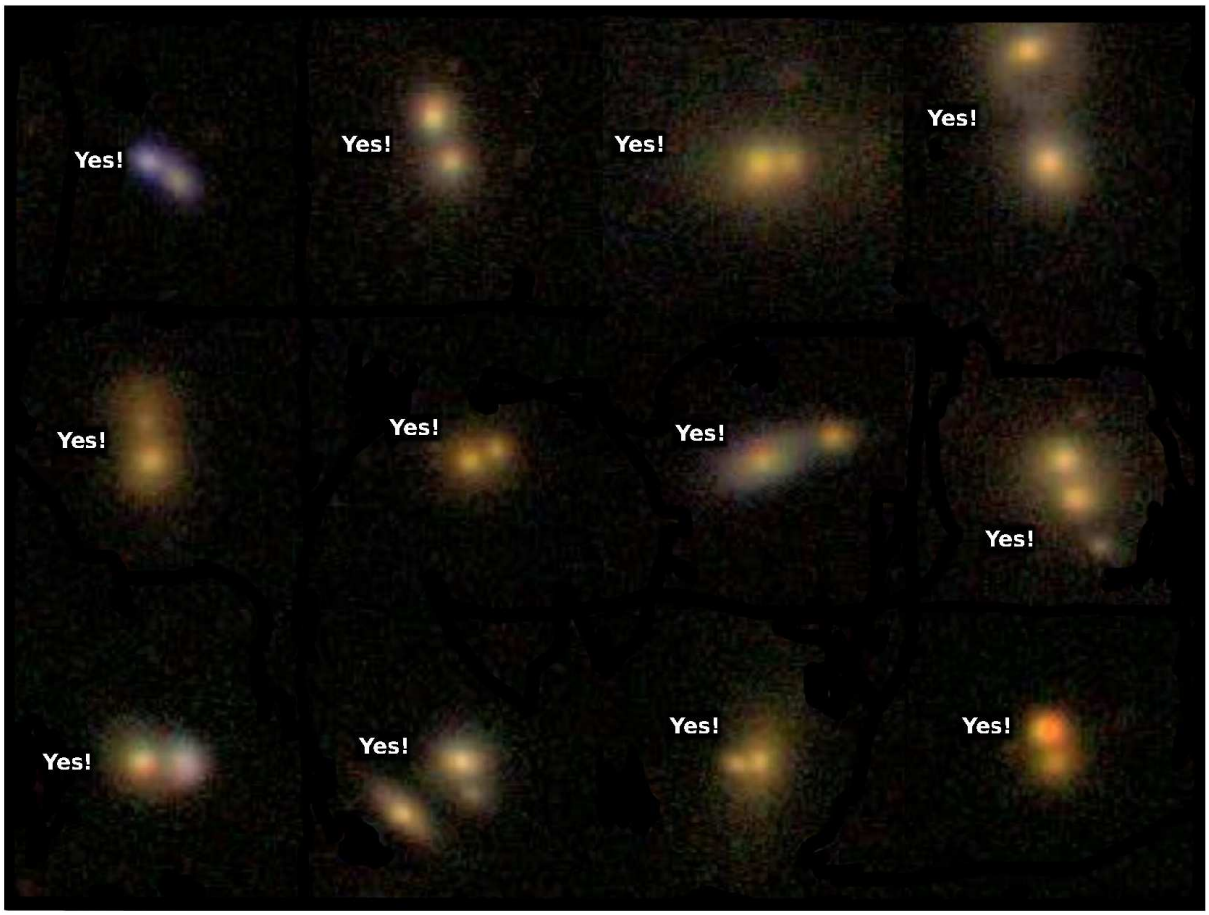

Figure 5: Example images from the 40-60% group. Comments: all of these are good mergers. The upper galaxy in (12) looks slightly star like due to its brightness and slow cut-off but is defiantly an interacting galaxy as seen by the tidal tails and blending between objects.

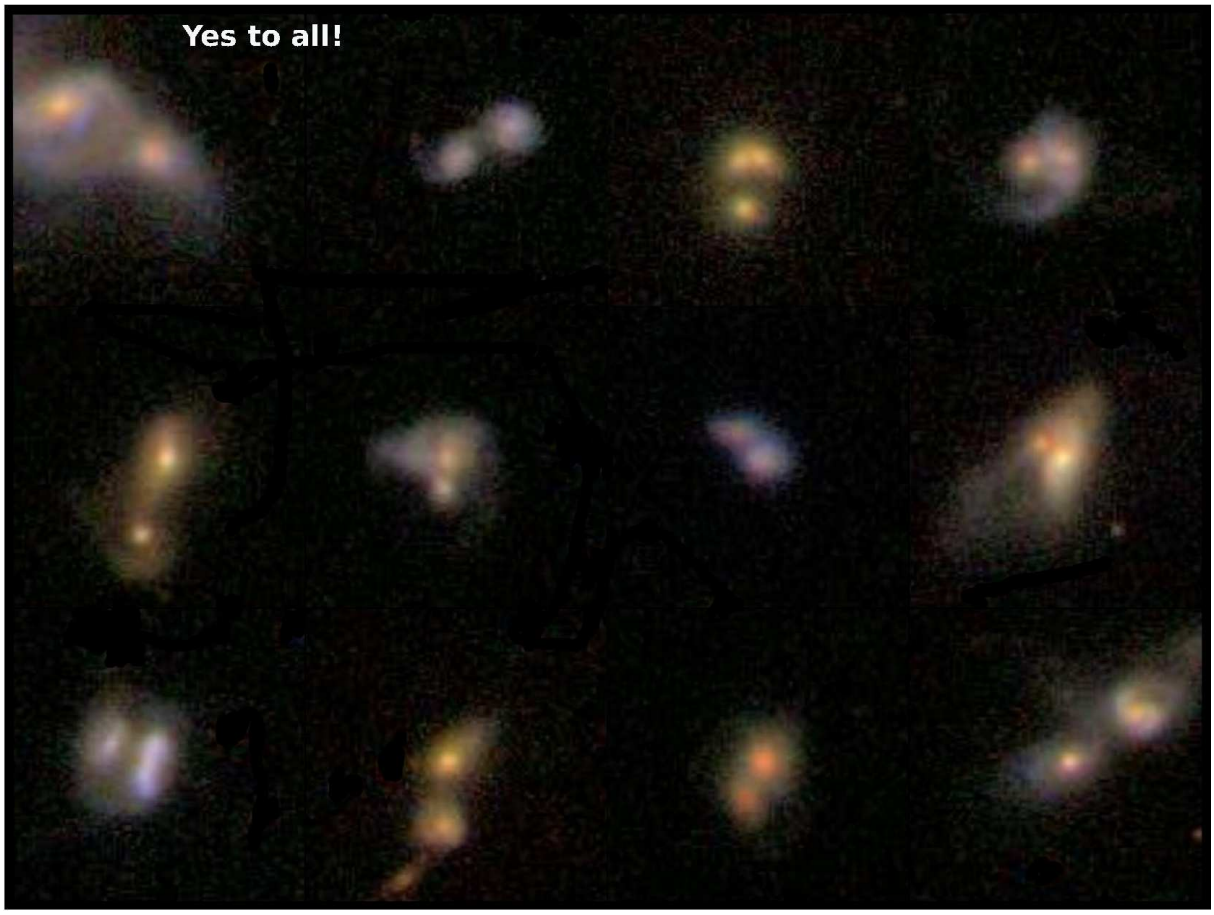

Figure 6: Example images from the 60-100% group. Comments: these are all fantastic objects! The Galaxy Zoo community has done science a great service by finding these. Thanks!