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Article

Remarkable spiral galaxies in Dark Energy Survey Data Release 2

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Abstract: A visual study of spiral galaxies from a subset of spiral galaxies in the Dark Energy Survey Data Release 2 finds that a significant number show long tails of baryonic matter, often much longer than the apparent diameter of the galaxy. Examples from less than 10% of the candidates are shown here and their possible origin is discussed. The tails were only seen connected to spiral galaxies; no examples of tails connected to elliptical galaxies or to artifacts were found. In many examples the tail is associated with what appears to be a colliding galaxy, but in many others there is no sign of one. An intriguing possibility is that in the latter cases the tails are produced by an encounter with an unseen object, either a massive black hole or a compact galaxy with mostly dark matter.

Keywords: Galaxies; anomalies; dark matter; colliding galaxies

1. Introduction

The Dark Energy Survey (DES) is an imaging survey based on optical/near-infrared imaging by the Dark Energy Camera on the 4-m Blanco telescope at the Cerro Tololo InterAmerican Observatory in Chile that covers 5000 deg^2 of the southern Galactic cap in five broad photometric bands, *grizY*. A recent public data release, Data Release 2 (DR2), comprises reduced images, source catalogs, and associated data products assembled from six years of DES science operations[1].

2. Methods

An SQL query (Appendix I) to the DES DataBaseAccess [2] was used to select spiral galaxy candidates. This yielded 119,814 candidates that were then scanned visually for a spiral topology. About half of this sample were found to be identifi-

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able spiral galaxies. Only about 10% of these have been scanned so far. Among these ~0.4% exhibited long tails. Some of these are exhibited in Fig. 1(a,b,c,…,v). These can be studied in detail using the DES Sky Viewer [3]. Convenient tools in the Sky Viewer allow the user to zoom in and out and to change the contrast so that a wide range of magnitudes can be covered. Table I gives links for each of the images in Fig. 1. The images in Fig. 1 have been reproduced at high contrast in order to show the tails more clearly. This introduces artifacts that appear as brightly colored crosses in the images where there is a bright object.

Unfortunately redshifts are not yet available for the DR2 survey. This makes understanding the long tails more difficult.

4. Discussion

It is important to note that the tails were only seen connected to spiral galaxies. All examples appear to lie generally in the plane of the spiral disc. No examples of similar tails connected to elliptical galaxies or to artifacts were seen despite the fact that a much larger region of the sky around the candidate spirals was viewed in the scan.

The images in Fig. 1(a-u) all show one or more long tails. In (a, b, c, d, e, f) there is a single long tail that extends out from the brighter part of the galaxy. There is no sign of a nearby galaxy that might have collided with the spiral.

In most of the others there are two tails, and many appear to have undergone collisions with nearby galaxies though without redshift information it is hard to tell if the other galaxy is actually nearby. The tails appear to be baryonic matter drawn (or ejected) from one of the spiral arms.

An intriguing possibility is that the single-tail/no-collision examples are the result of an encounter with an unseen 'dark' object – either a massive black hole or a compact galaxy with mostly dark matter. – This scenario could also account for some of the double-tailed examples with the shorter tail produced when the dark object approaches and the long tail produced as it moves away, pulling baryonic matter

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from the spiral galaxy along with it. Elliptical galaxies, being more tightly bound than spirals, would be much less susceptible to be torn apart in this manner.

If the encounter with an unseen object interpretation is correct it would mean that such objects are rather common since the frequency of tails with no obvious galaxy nearby is comparable to that in which a nearby visible galaxy is seen.

The reader is encouraged to explore these examples on their own by inserting the Sky Viewer links in Table I into their web browser in order to appreciate how striking and unusual these tails are. Convenient tools in the Sky Viewer allow the user to zoom in and out and to change the contrast so that a wide range of magnitudes can be covered. It may be necessary to set up a free user account.

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Table I – Links to Images

(a) https://desportal2.cosmology.illinois.edu/sky/#sky/41/34%2C66064%2B-45%2C08122/0,03
(b) https://desportal2.cosmology.illinois.edu/sky/#sky/41/74%2C71430%2B-21%2C56392/0,13
(c) https://desportal2.cosmology.illinois.edu/sky/#sky/41/8%2C84996%2B3%2C39151/0,07
(d) https://desportal2.cosmology.illinois.edu/sky/#sky/41/8%2C68621%2B-2%2C88544/0,13
(e) https://desportal2.cosmology.illinois.edu/sky/#sky/41/82%2C54917%2B-49%2C73553/0,07
(f) https://desportal2.cosmology.illinois.edu/sky/#sky/41/50%2C66874%2B-46%2C56803/0,03
(g) https://desportal2.cosmology.illinois.edu/sky/#sky/41/81%2C49847%2B-25%2C26045/0,03
(h) https://desportal2.cosmology.illinois.edu/sky/#sky/41/26%2C94277%2B-20%2C09488/0,03
(i) https://desportal2.cosmology.illinois.edu/sky/#sky/41/79%2C09804%2B-57%2C19503/0,03
(j) https://desportal2.cosmology.illinois.edu/sky/#sky/41/328%2C92930%2B-56%2C11030/0,03
(k) https://desportal2.cosmology.illinois.edu/sky/#sky/41/345%2C92088%2B1%2C04378/0,04
(l) https://desportal2.cosmology.illinois.edu/sky/#sky/41/339%2C17538%2B-61%2C39738/0,13
(m) https://desportal2.cosmology.illinois.edu/sky/#sky/41/77%2C11108%2B-37%2C65675/0,03
(n) https://desportal2.cosmology.illinois.edu/sky/#sky/41/6%2C50769%2B-2%2C93343/0,03
(o) https://desportal2.cosmology.illinois.edu/sky/#sky/41/60%2C50621%2B-39%2C45506/0,06
(p) https://desportal2.cosmology.illinois.edu/sky/#sky/41/35%2C75208%2B-29%2C76403/0,13
(q) https://desportal2.cosmology.illinois.edu/sky/#sky/41/10%2C19598%2B-51%2C46656/0,06
(r) https://desportal2.cosmology.illinois.edu/sky/#sky/41/329%2C96444%2B-56%2C99261/0,01
(s) https://desportal2.cosmology.illinois.edu/sky/#sky/41/351%2C77125%2B0%2C72658/0,07
(t) https://desportal2.cosmology.illinois.edu/sky/#sky/41/26%2C95301%2B-61%2C35001/0,03
(u) https://desportal2.cosmology.illinois.edu/sky/#sky/41/1%2C49688%2B-36%2C12767/0,13
(v) https://desportal2.cosmology.illinois.edu/sky/#dataset/51784/63%2C53742%2B-55%2C70733/0,07

References

1. Dark Energy Collaboration; arXiv:2101.05765v1 [astro-ph.IM] 14 Jan 2021
2. https://des.ncsa.illinois.edu/desaccess/db-access
3. https://desportal2.cosmology.illinois.edu/sky/#sky/41

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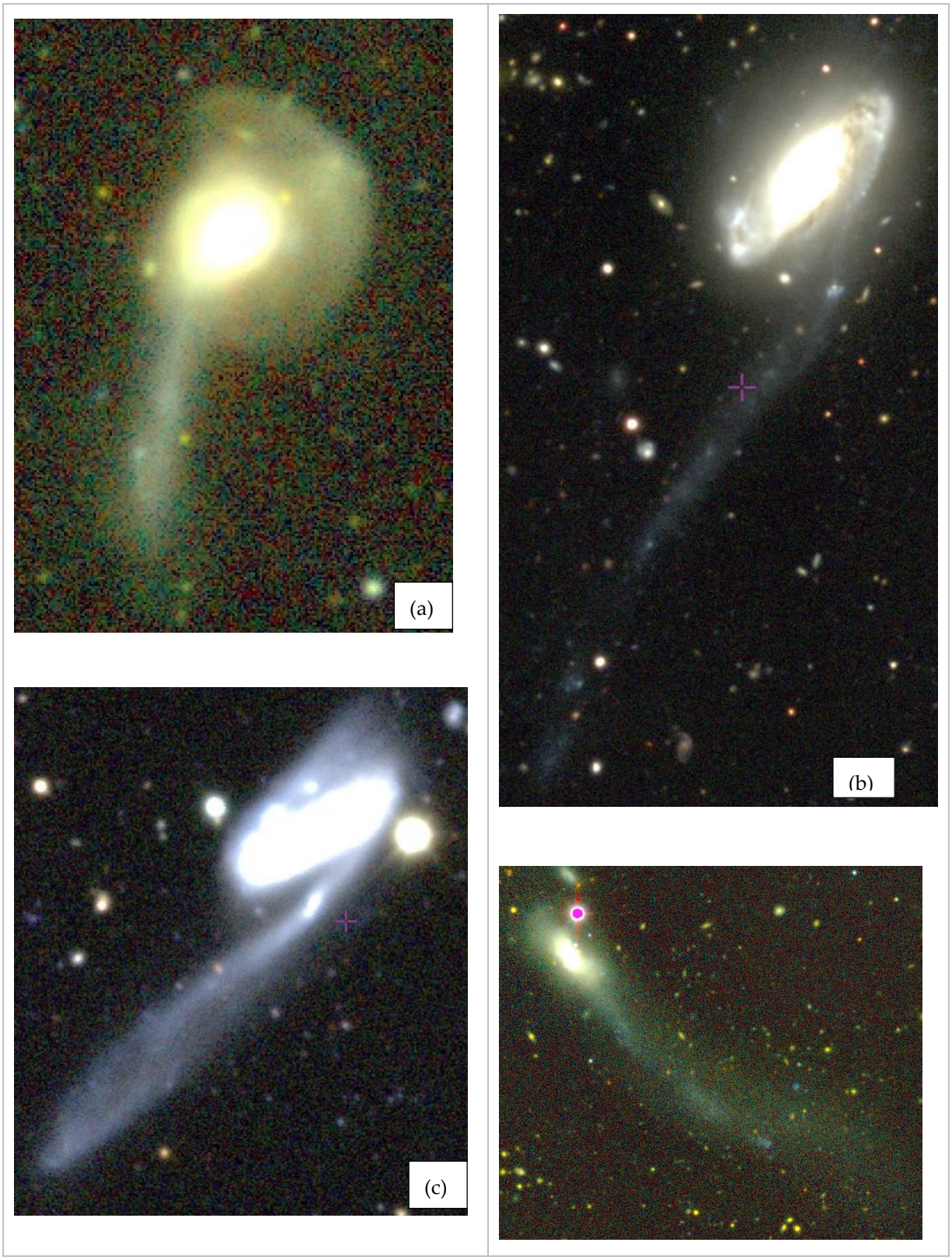

Figure 1– Examples of spiral galaxies with long tails

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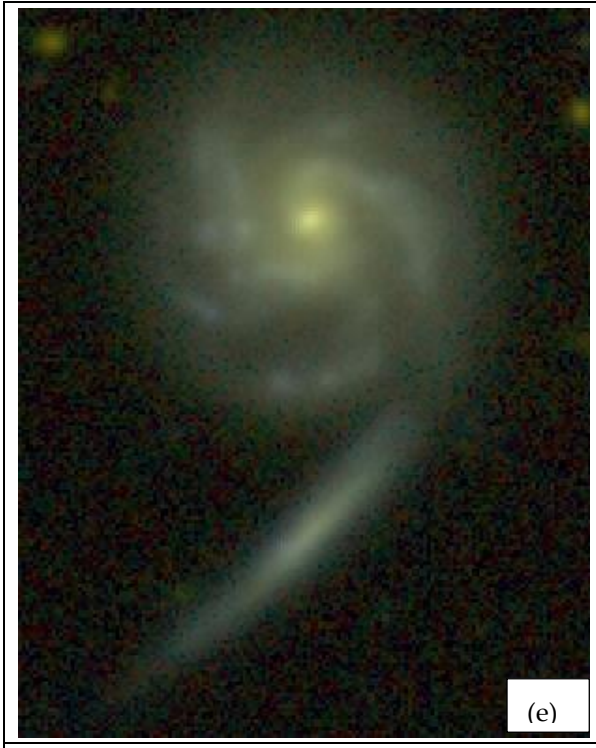

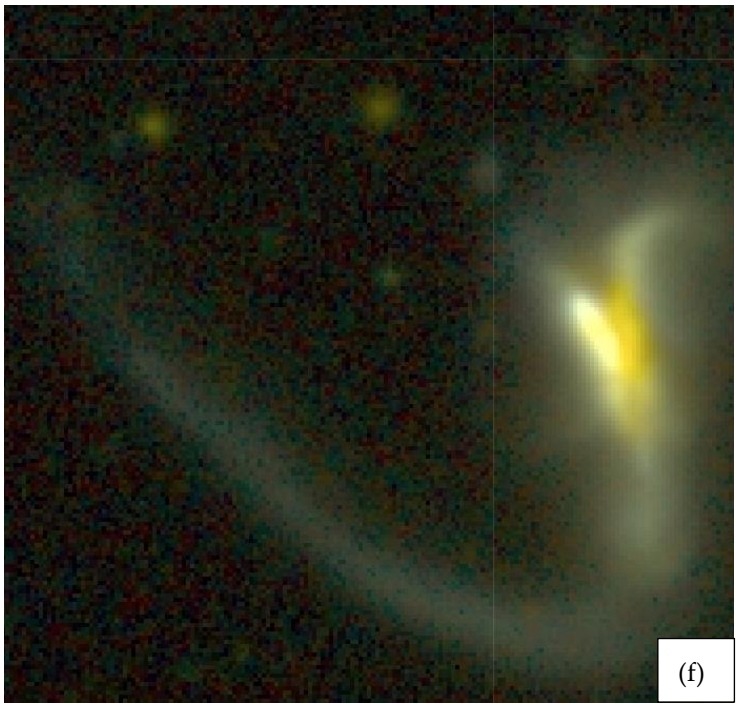

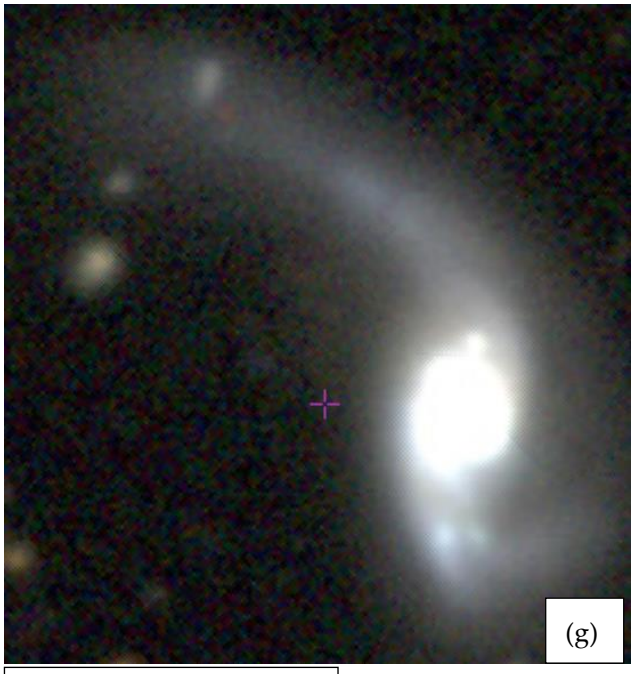

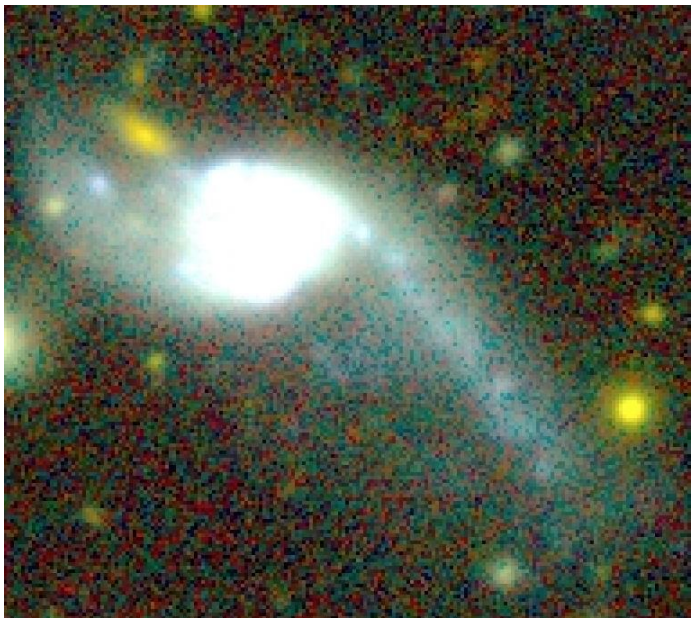

Figure 1– cont'd. 1

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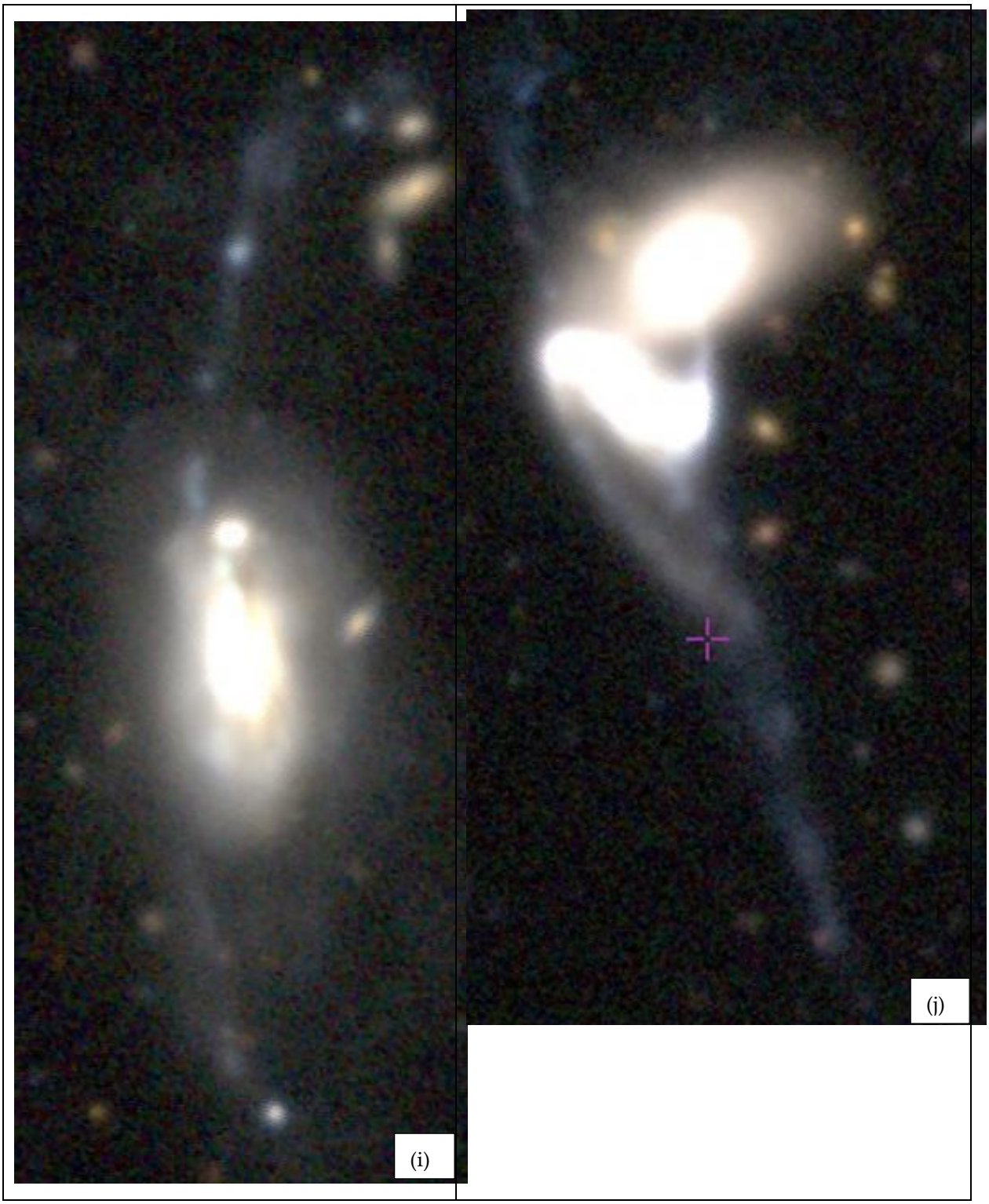

Figure 1– cont'd. 2

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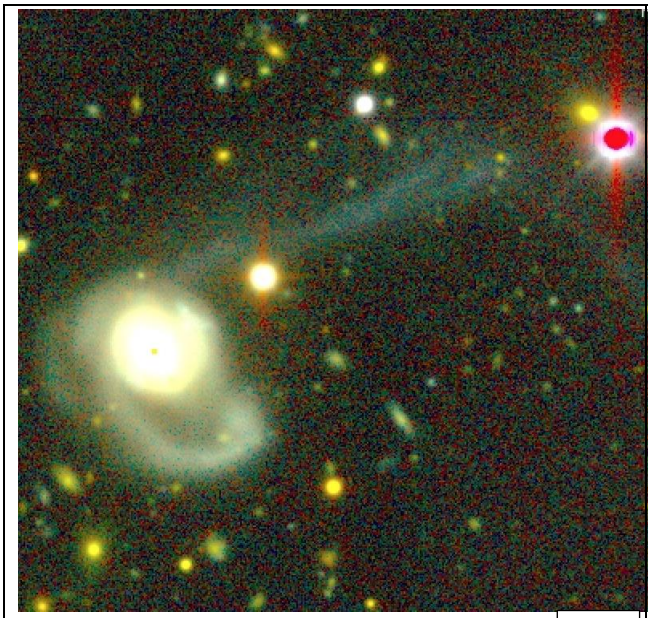
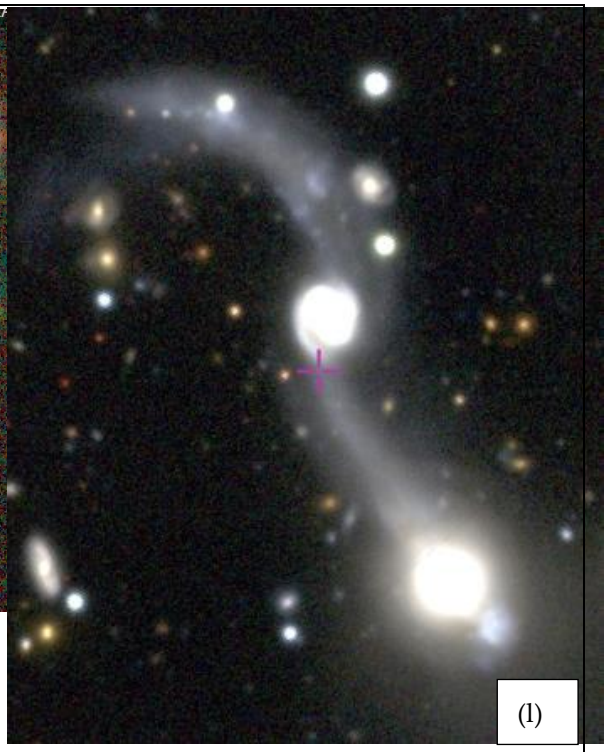
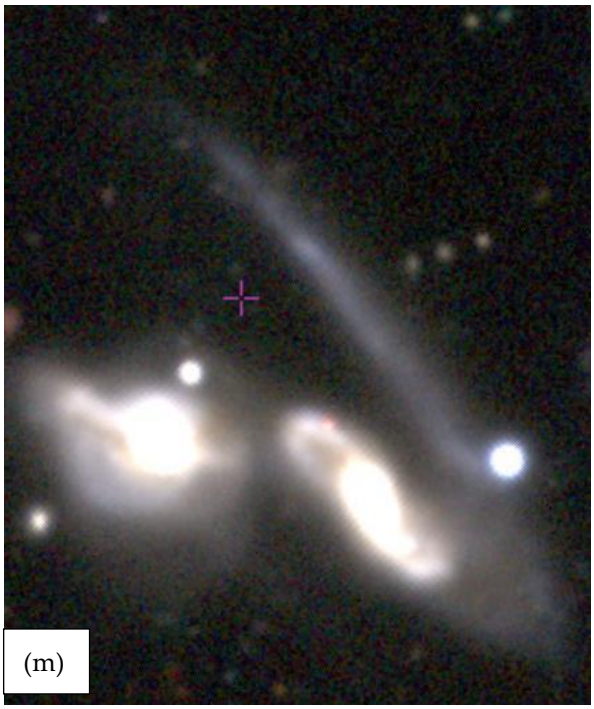


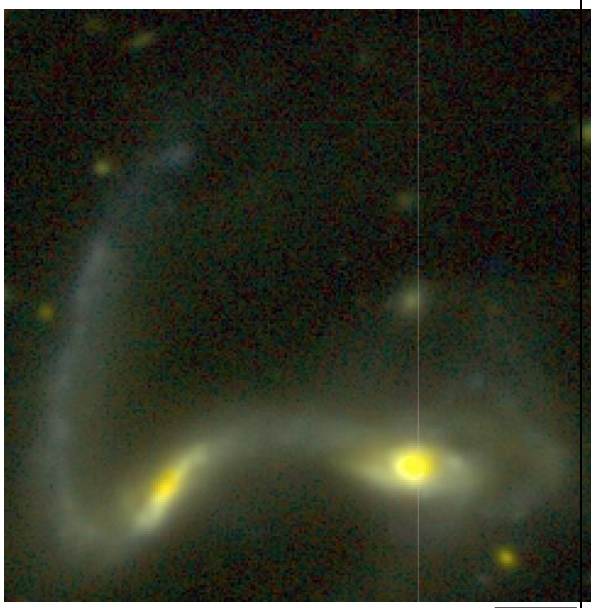
(k)



(l)



(m)



(n)

Figure 1– cont'd., 3

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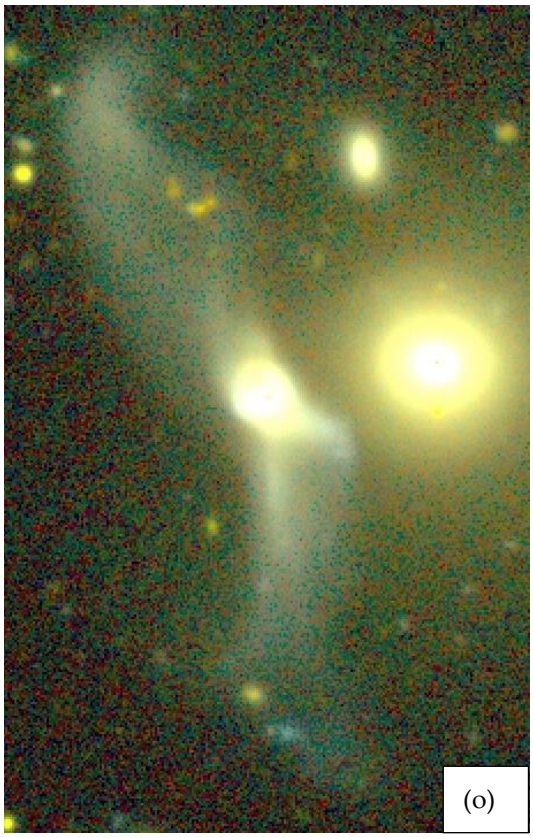

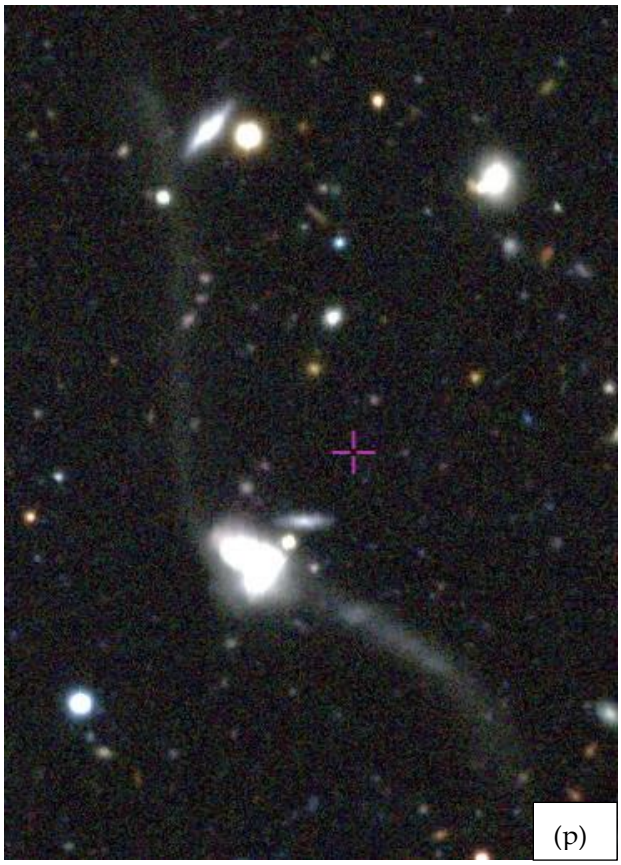

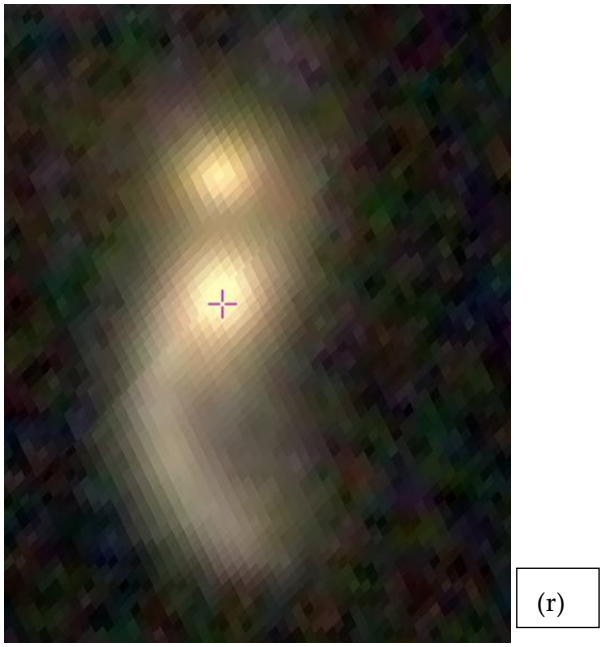

Figure 1– cont'd., 4

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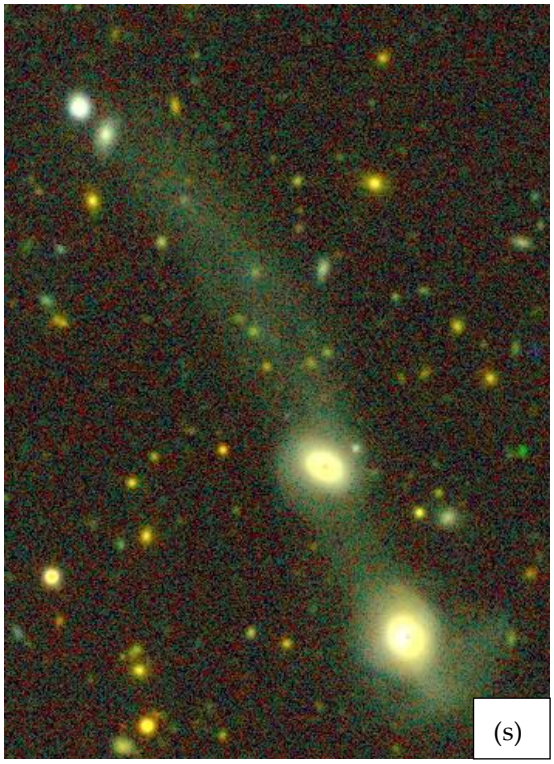

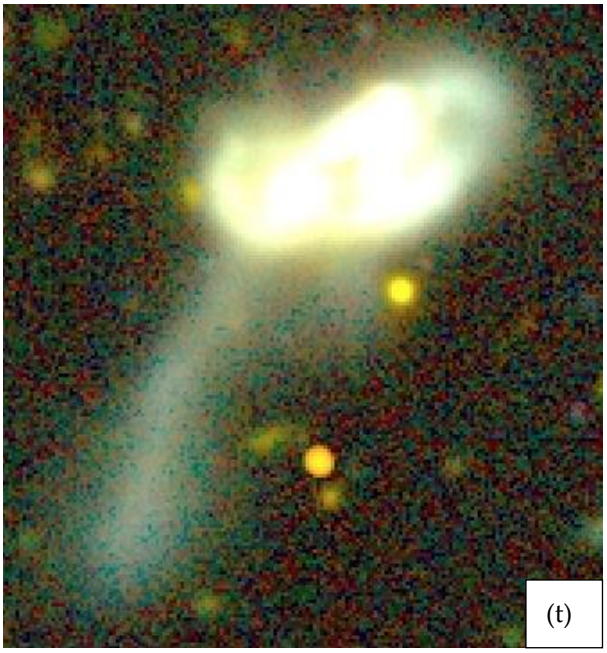

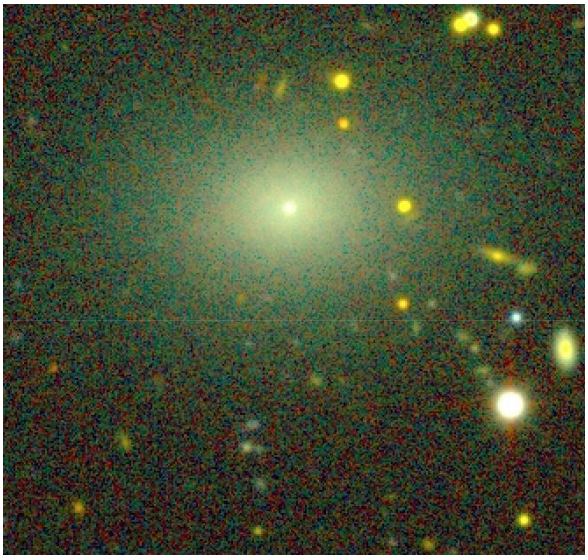

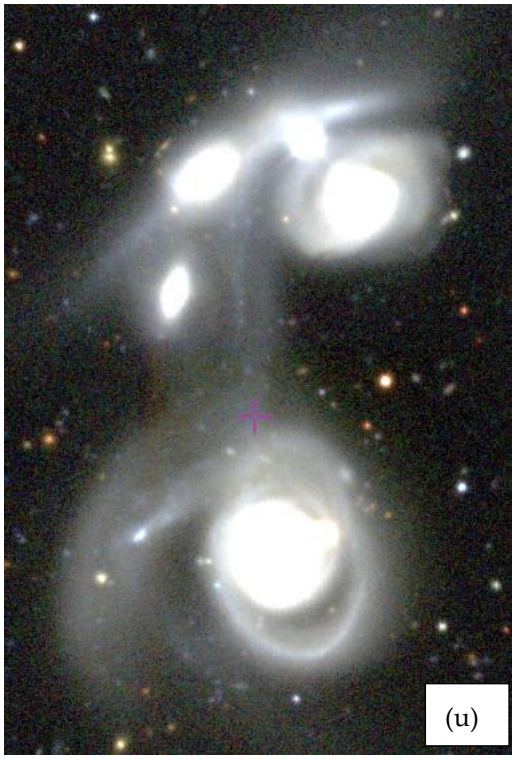

This image seems to show an 'explosion' or alignment, not a faint tail. It is included for completeness.

Figure 1– cont'd., 5

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Appendix I – SQL query used to select spiral galaxy candidates from DR2 data base

```
SELECT dr2.RA RA, dr2.DEC DEC, dr2.COADD_OBJECT_ID ID,
MAG_AUTO_G,MAG_AUTO_R,MAG_AUTO_I,MAG_AUTO_Z
FROM DR2_MAIN dr2
WHERE
  dr2.MAG_AUTO_G < 18 and
  dr2.MAG_AUTO_R < 19 and
  dr2.WAVG_SPREAD_MODEL_I + 3.0*dr2.WAVG_SPREADERR_MODEL_I > 0.005
and
  dr2.WAVG_SPREAD_MODEL_I + 1.0*dr2.WAVG_SPREADERR_MODEL_I > 0.003
and
  dr2.WAVG_SPREAD_MODEL_I - 1.0*dr2.WAVG_SPREADERR_MODEL_I > 0.001
and
  dr2.WAVG_SPREAD_MODEL_I > -1 and
  dr2.IMAFLAGS_ISO_G = 0 and
  dr2.IMAFLAGS_ISO_R = 0 and
  dr2.IMAFLAGS_ISO_I = 0 and
  dr2.FLAGS_G < 4 and
  dr2.FLAGS_R < 4 and
  dr2.FLAGS_I < 4 and
  dr2.NEPOCHS_G > 0 and
  dr2.NEPOCHS_R > 0 and
  dr2.NEPOCHS_I > 0 and
  (MAG_AUTO_G - MAG_AUTO_R) < 0.75    -- Select bluer galaxies
```