Peas in my Cosmic Fruit Salad? Investigating Young Galaxies from the Early Universe

Green Peas (GPs; Cardamone et al. 2009) are a class of low-redshift (z ~ 0.1 - 0.4) extreme emission-line galaxies characterized by intense star formation, strong nebular emission lines, low metallicity, minimal dust content, and high gas pressure. These galaxies are compact, with typically low stellar masses. They were first identified by citizen scientists in the Galaxy Zoo project[1] due to their distinct compact (a few arcseconds across) green appearance in Sloan Digital Sky Survey (SDSS) images, caused by strong [O III] emission around 500 nm (see Figure 1).
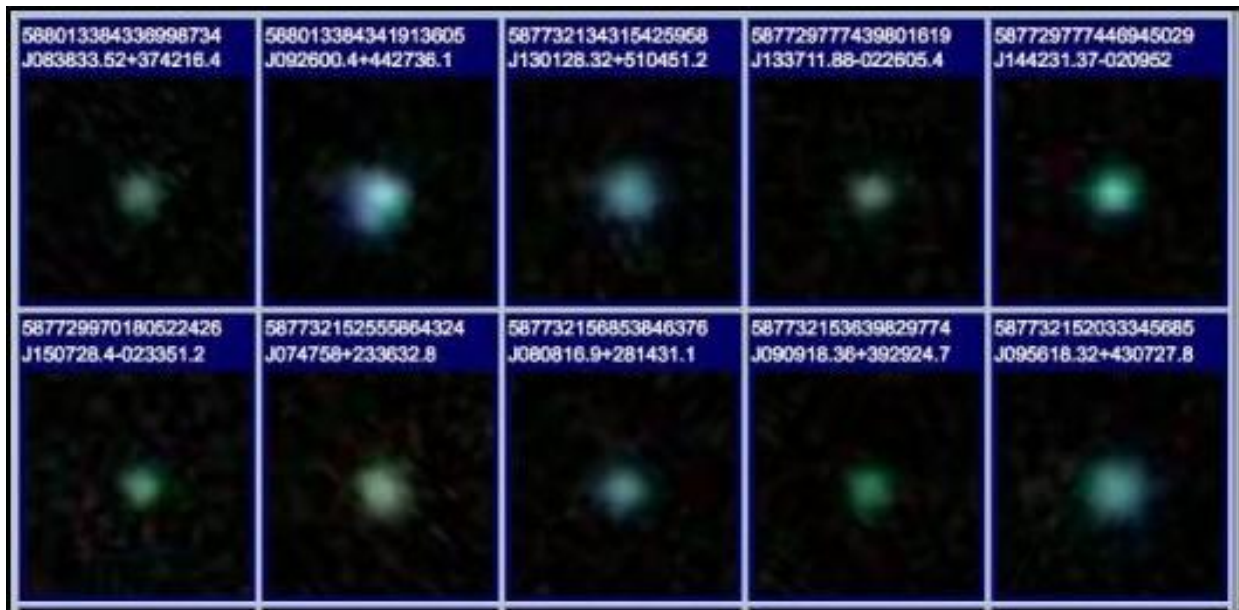

Figure 1: Some example Green Pea (GP) galaxies. Image Credit: Richard Nowell & Carolin Cardamone

Following the discovery of Green Pea galaxies, two related classes—Blueberry (BB) and Purple Grape (PG) galaxies, with lower redshifts (z ~ 0.02)—have also been identified (see Figure 2). Together, this "fruit salad" of GP, BB, and PG galaxies resembles galaxies from the universe's early stages, providing a unique opportunity to study how stars and galaxies formed shortly after the Big Bang. Studying these galaxies allows us to explore how extreme starburst conditions drive galaxy evolution, examine the processes that fuel star formation, and gain insights into reionization in the early universe.

Another intriguing aspect of these galaxies is their potential association with active galactic nuclei (AGN), suggesting they may host supermassive black holes. A recent study using photometric colours and light-curve variability from the Wide-field Infrared Survey Explorer (WISE) telescope has identified at least two Green Pea candidates that may host AGNs (Harish et al. 2023).

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[1] https://blog.galaxyzoo.org/2015/07/07/eight-years-the-8th-paper-green-peas-living-fossils-of-galaxy-evolution/
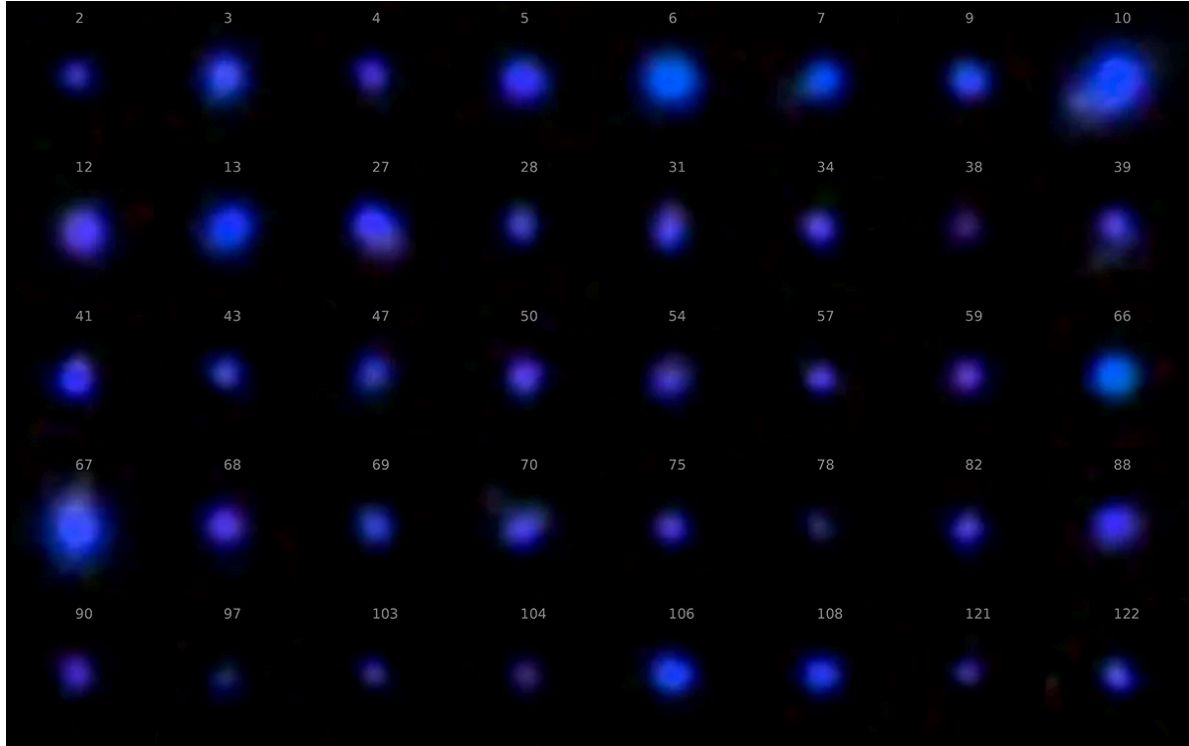
Figure 2: Some example Blueberry (BB) galaxies. Image Credit: Sloan Digital Sky Survey, Huan Yang

The aim of this honours project is to extract photometric light curves for a known list of GP, BB and/or PG galaxies from the publicly available ATLAS Forced Photometry server[2], in order to analyse colour indices and detect any variability that may indicate additional galaxies hosting AGNs. Below is an example of one possible candidate extracted from the ATLAS archive:

Figure 3: (Left) An Example cutout stamp from the ATLAS archive showing an identified BB galaxy (14:35:11.541 +36:04:37.05) at the center of the frame. (Middle) Corresponding SDSS stamp showing the distinct blue colour of this very compact galaxy. (Right) Photometric light-curve data in the two custom "cyan" and "orange" filters of ATLAS showing a very small (even negative) *c-o* colour (i.e., a very "blue" colour) and clear variability over the ~8 years that the ATLAS archival data spans.

This work could lead to a publication if enough candidates are found and possibly form the basis of a future MSc project.

Further reading:

Cardamone et al. 2009: https://academic.oup.com/mnras/article/399/3/1191/1073770
Harish et al. 2023: https://iopscience.iop.org/article/10.3847/1538-4357/acb99c

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