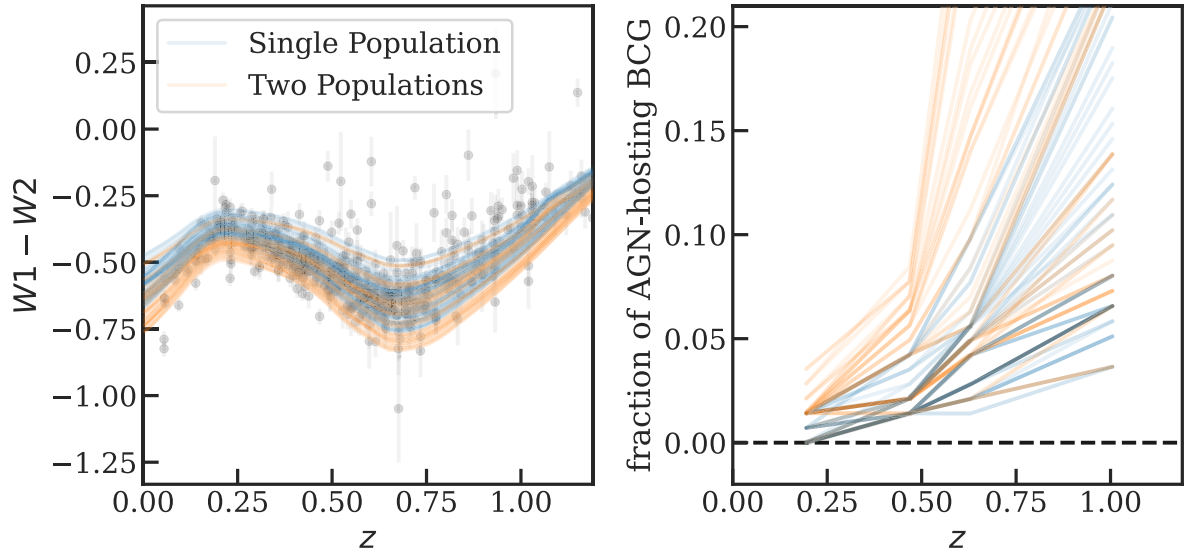

Figure 4. Left: W1–W2 colors (black dots) for each BCG candidate in this sample. The solid lines show the expected color as a function of redshift using EzGal models for both a single-burst stellar population (blue) and the two-age stellar populations (orange). The single-burst models are plotted from a wide range of parameters, including two IMF (Salpeter 1955; Chabrier 2003), three formation redshifts ($z_f = 1.5$, 2.5, and 3.5), and a span of metallicity from 0.75 to 1.0 $Z_\odot$. To obtain the best fit, we perform a grid search between the IMF and the three formation redshifts before fitting the metallicity to minimize the chi-square. The old and young stellar models use the same parameter sets, but include an additional "young" population, which is represented by a 50 Myr old stellar population at all observed redshifts. Right: The fraction of AGN-hosting BCGs as a function of redshift for all models. The figure demonstrates that the fraction of AGN-hosting BCGs increases with redshift regardless of our choice of stellar population model.

3.1.2. Spitzer Color Verification

Because the point-spread functions (PSFs) of the two WISE bands are not small (PSF $_{W1} = 6\farcs08$ and PSF $_{W2} = 6\farcs84$), we compare the results from WISE mid-IR color with those from the Spitzer Space Telescope. Spitzer is an IR telescope with the Infrared Array Camera (IRAC; Fazio et al. 2004) as one of its main science instruments. IRAC is a four-channel imaging camera capable of taking simultaneous images at wavelengths of 3.6, 4.5, 5.8, and 8.0 μm. Thus, channels 1 and 2 ([3.6] and [4.5]) on IRAC are roughly equivalent with $W1$ and $W2$ from WISE, but with the benefit of having a much better PSF at $1\farcs95$ and $2\farcs02$, respectively (Fazio et al. 2004).

A certain fraction (∼35%, predominantly at $z > 0.8$) of the SPT cluster sample has been observed with IRAC. For verification, we compare the [3.6]–[4.5] colors of our AGN-hosting BCG candidates with their $W1$–$W2$ colors. If the Spitzer color, which has a higher angular resolution, is bluer (smaller) than the WISE color, it shows that there is a contamination from nearby galaxies within the WISE aperture. On the other hand, if the Spitzer color is redder (larger), it implies that the object is even more likely to be an AGN. Figure 5 shows the comparison between WISE's $W1$–$W2$ (gray squares) and Spitzer's [3.6]–[4.5] color (circles) for our AGN candidates. We find that most AGN candidates have a difference of Spitzer and WISE color that is either compatible (60% of the sources have a difference of within ±0.07 mag, which is roughly the mean of the WISE color uncertainty) or that Spitzer is slightly redder (33% of the sources have a Spitzer color larger than the WISE color by ∼0.2 mag). This suggests that most of our AGN candidates are likely to be real quasars. One clear exception is SPT-CL J2146-4633, which has a WISE color much redder than Spitzer. Further investigation shows that there is a point-like source near the location of the object, but not at the BCG location, meaning that the WISE color is probably contaminated by a nearby AGN, while the Spitzer color is not. This object has been removed from the further analysis.

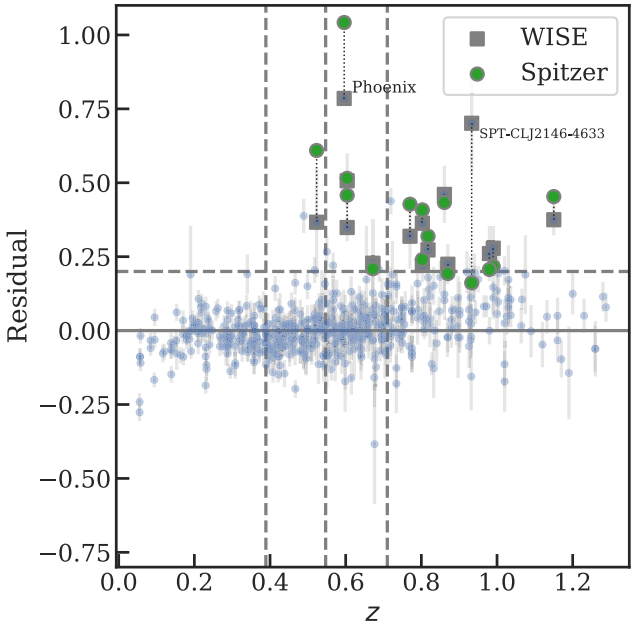

Figure 5. Residual plot similar to the bottom panel of Figure 3. The blue points are the $W1$–$W2$ color difference between each BCG candidate and the expected color. The gray squares emphasize the $W1$–$W2$ color from WISE for the sample that has been observed by Spitzer, while the green circles show the color from Spitzer, demonstrating that most of the objects we classify as AGNs have a difference of Spitzer and WISE color that is either compatible (60% of the sources have a difference of within ± 0.07 mag) or Spitzer is slightly redder (33% of the sources have a Spitzer color larger than the WISE colr by ∼0.2 mag). This means that the color and our results are not strongly impacted by WISE's larger PSF.