A star formation study of the ATLAS^{3D} early-type galaxies with the AKARI all-sky survey

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ABSTRACT

Context. The star formation properties of early-type galaxies (ETGs) are currently the subject of considerable interest, particularly whether they differ from the star formation properties of gas-rich spirals.

Aims. We perform a systematic study of star formation in a large sample of local ETGs with polycyclic aromatic hydrocarbon (PAH) and dust emission, focusing on the star formation rates (SFRs) and star formation efficiencies (SFEs) of the galaxies.

Methods. Our sample is composed of the 260 ETGs from the ATLAS^{3D} survey, from which we used the cold gas measurements (HI and CO). We estimated the SFRs from stellar, PAH, and dust fits to spectral energy distributions created from new AKARI measurements and with literature data from WISE and 2MASS.

Results. The mid-infrared luminosities of non-CO-detected galaxies are well correlated with their stellar luminosities, showing that they trace (circum)stellar dust emission. CO-detected galaxies show an excess above these correlations, uncorrelated with their stellar luminosities, indicating that they likely contain PAHs and dust of interstellar origin. PAH and dust luminosities of CO-detected galaxies show tight correlations with their molecular gas masses; the derived current SFRs are typically $0.01\text{--}1\ M_{\odot}\ \text{yr}^{-1}$. These SFRs systematically decrease with stellar age at fixed stellar mass, while they correlate nearly linearly with stellar mass at fixed age. The majority of local ETGs follow the same star formation law as local star-forming galaxies and their current SFEs do not depend on either stellar mass or age.

Conclusions. Our results clearly indicate that molecular gas is fueling current star formation in local ETGs, which appear to acquire this gas via mechanisms regulated primarily by stellar mass. The current SFEs of local ETGs are similar to those of local star-forming galaxies, indicating that their low SFRs are likely due to smaller cold gas fractions rather than a suppression of star formation.

Key words. galaxies: elliptical and lenticular, cD – galaxies: ISM – galaxies: photometry – dust, extinction – infrared: galaxies – galaxies: star formation

1. Introduction

Stellar population studies of local early-type galaxies (ETGs; ellipticals and lenticulars) show that they are dominated by old stars and reside in the so-called red sequence of the optical colour-magnitude diagram. This suggests that they ceased to form stars at an early stage of their evolution (e.g. Cowie et al. 1996; Thomas et al. 2010), and thus represent the end point of galaxy evolution.

The interstellar space of ETGs is generally filled with hot X-ray gas (e.g. Forman et al. 1985) that can heat and destroy any cold interstellar medium (ISM), which is the fuel for star formation. Nevertheless, atomic gas, molecular gas, and dust have all been detected in a large amount of ETGs (e.g. Knapp et al. 1985, 1989; Wardle & Knapp 1986; Knapp & Rupen 1996), and evidence for the presence of such cold gas and dust in ETGs has grown for the last two decades through both radio and infrared (IR) observations. In particular, Young et al. (2011) carried out a molecular gas survey of the 260 ETGs in the ATLAS^{3D} sample (Cappellari et al. 2011), which aimed to reveal the formation and evolutionary processes of nearby ETGs. With a high detection rate of 22%, Young et al. confirmed that molecular gas is prevalent in ETGs, suggesting that some ETGs may still be able

to form new stars. Far-infrared (FIR) emission from cold dust in ETGs was systematically investigated first with the Infrared Astronomical Satellite (IRAS; Knapp et al. 1989). More recent observations with satellites such as the Infrared Space Observatory (ISO), *Spitzer*, AKARI, and *Herschel* also detected dust of both circumstellar and interstellar origin in many ETGs (e.g. Temi et al. 2003; Kaneda et al. 2011; Smith et al. 2012). Polycyclic aromatic hydrocarbons (PAHs), which are destroyed by X-rays much more easily than dust, are also detected in some ETGs (e.g. Kaneda et al. 2005, 2008; Rampazzo et al. 2013). As PAHs are considered a star formation tracer, their presence in ETGs again suggests that star formation is ongoing. Indeed, PAHs are excited and ionised by far-ultraviolet (FUV) light from young stars, producing strong features primarily at wavelengths of 6.2, 7.7 and 8.6 μm , while they are destroyed by hard UV and X-ray radiation from active galactic nuclei (AGN; e.g. Peeters et al. 2004).

Shapiro et al. (2010) investigated the star formation properties of the 48 ETGs in the SAURON sample using PAH emission observed with *Spitzer* (de Zeeuw et al. 2002); they argued that ETGs form stars with surface densities and efficiencies similar to those of spiral galaxies. These authors also suggested that star formation in ETGs proceeds in at least two different modes,

i.e. widespread and circumnuclear, which may reflect different evolutionary paths. With PAH and mid-infrared emission (MIR), Crocker et al. (2011) calculated the current star formation rates (SFRs) of the SAURON ETGs, and suggested that they form stars less efficiently than spiral galaxies. Using both numerical simulations and observational results, Martig et al. (2013) similarly argued that ETGs have lower star formation efficiencies (SFEs; defined as the SFR per unit cold gas mass M_{gas}) than spiral galaxies, which is likely due to the increased stability of discs embedded in spheroids. The same trend is reported in the ATLAS^{3D} sample using SFRs estimated from MIR and FUV light (Davis et al. 2014). It has also been suggested that AGN and galaxy mergers can respectively heat (and expel) and strip away the cold ISM of ETGs, thus suppressing star formation, i.e. lowering the SFE (see e.g. Schawinski et al. 2006; Nesvadba et al. 2011; Alatalo et al. 2015; Guillard et al. 2015; Lanz et al. 2016). It is therefore likely that while ETGs have a substantial cold ISM and are forming stars, their SFE is reduced with respect to that of spiral galaxies because of a number of properties and mechanisms particular to ETGs.

In a different vein, the sources of the cold ISM in ETGs are themselves a matter of debate. As mentioned above, the stellar populations of ETGs are uniformly old, indicating that the original cold gas reservoirs that led to galaxy formation have already been consumed (e.g. Bower et al. 1992). In addition, old stars do not efficiently produce dust and ETGs are filled with hot X-ray gas, which can destroy dust through sputtering (e.g. Draine & Salpeter 1979). Yet Goudfrooij & de Jong (1995) clearly demonstrated that ellipticals contain more dust than that expected from the balance between production via stellar mass loss (e.g. Faber & Gallagher 1976) and destruction via X-ray sputtering. Galaxy mergers are therefore frequently invoked as a possible mechanism to supply cold gas and dust to ETGs. For example, Davis et al. (2011) studied the kinematics of stars, ionised gas, and molecular gas in ETGs and, owing to the pervasiveness of kinematic misalignments between stars and gas, suggested that the majority of ETGs may obtain cold gas from external sources. Internal sources are however also proposed by several authors. For example, based on the spatial distribution of dust and X-ray gas, it has been suggested that intermittent buoyant outflows from low-luminosity AGN can replenish dust in ellipticals (e.g. Temi et al. 2007; Kaneda et al. 2011). Continuous dust production by old stars and dust growth in the ISM are other potential channels for dust production in ETGs (Martini et al. 2013; Hirashita et al. 2015).

Depending on how ETGs obtain their gas and dust, star formation may well proceed differently. A systematic study of the cold ISM properties of a large sample of ETGs, coupled with constraints on their star formation activity, is thus essential to properly understand ETG evolution. Here, we systematically investigate the star formation properties of the ATLAS^{3D} ETGs with PAH and dust emission measured from the AKARI all-sky survey, combined with Wide-field Infrared Survey Explorer (WISE) and Two Micron All Sky Survey (2MASS) archival data, and atomic and molecular gas data from ATLAS^{3D}. We detail our measurements in Sect. 2 and present the main results in Sect. 3. The star formation properties of ETGs are discussed in Sect. 4 and we summarise our results in Sect. 5.

2. Sample and data

2.1. ATLAS^{3D} survey

The goal of the ATLAS^{3D} project was to conduct a comprehensive study of a complete, volume-limited sample of

260 morphologically selected local ETGs ($M_K < -21.5$ and $D < 42$ Mpc; Cappellari et al. 2011). A diverse range of observations and simulations was performed, at its core optical integral-field spectroscopic observations with the SAURON instrument (Bacon et al. 2001), yielding detailed information on the stellar kinematics (Krajnović et al. 2011, 2013a,b; Emsellem et al. 2011) and populations (Cappellari et al. 2012; Scott et al. 2013; McDermid et al. 2014, 2015). In addition to single-dish molecular gas surveys (Combes et al. 2007; Young et al. 2011), both H I and CO interferometric observations were obtained (Young et al. 2008; Crocker et al. 2011; Serra et al. 2012; Alatalo et al. 2013). The morphology and kinematics of the molecular gas are characterised in Davis et al. (2013), while its physical conditions are discussed in Crocker et al. (2012) and Bayet et al. (2013).

2.2. AKARI all-sky survey

The new IR fluxes presented here were obtained from the AKARI satellite (Murakami et al. 2007) all-sky surveys in the MIR (central wavelengths 9 and 18 μm ; Onaka et al. 2007) and FIR (65, 90, and 140 μm ; Kawada et al. 2007). For the MIR 9 and 18 μm bands, the total galaxy flux densities were obtained through aperture photometry as follows. First, we applied a spatial filtering of 1.3 arcmin^{-1} to each galaxy image to remove periodic noise. Second, we performed aperture photometry on the all-sky diffuse maps (Doi et al. 2015; Ishihara et al., in prep.), within a circular aperture of radius $R_{\text{aper}} = \sqrt{(2R_e)^2 + (1.5D_{\text{PSF}})^2}$, where R_e is the effective radius of each galaxy in the optical B band (Cappellari et al. 2011) and D_{PSF} is the full width at half maximum of the point spread function (PSF) of the AKARI instrument at the given wavelength (Ishihara et al. 2010; Takita et al. 2015). The average sky level was first measured in a circular annulus of inner radius $1.5 R_{\text{aper}}$ and outer radius $2.5 R_{\text{aper}}$, and was then subtracted from individual measurements. The uncertainty of the total flux density of a given object in a given band was estimated by appropriately propagating the uncertainty on individual measurements, taken as the standard deviation of the flux densities in the same sky annulus. For the FIR 65, 90, and 140 μm bands, the total galaxy flux densities were measured in an identical manner, but without the initial spatial filtering. Details of the measurement will be provided in the AKARI ETG catalogue (Kaneda et al., in prep.), in which integrated flux density measurements of ≈ 8000 ETGs selected from the HyperLeda catalogue (Makarov et al. 2014) will be detailed.

Overall, we measured AKARI flux densities for 258, 260, 245, 246, and 254 of the 260 ATLAS^{3D} ETGs in the 9, 18, 65, 90, and 140 μm bands, respectively; the missing measurements were due to incomplete AKARI sky coverage. When possible, the missing 65 and 90 μm flux densities were replaced by IRAS 60 and/or 100 μm measurements, as listed in the NASA/IPAC Extragalactic Database (NED)¹. In the 65, 90, and 140 μm bands, a further 52, 8 and 22 measurements, respectively, are likely affected by source confusion or instrumental artefacts and are thus excluded from our analysis. The MIR and FIR flux densities thus derived are listed in Table A.1.

It has already been shown that AKARI fluxes are in good agreement with analogous measurements by *Spitzer* and *Herschel* (Suzuki et al. 2010; Hattori et al. 2016), but we nevertheless check the quality of our measurement here by comparing our AKARI 90 and 140 μm flux densities with *Spitzer* and *Herschel* measurements. Among our sample, 89 galaxies

¹ <https://ned.ipac.caltech.edu/>

Fig. 1. Examples of galaxies with a strong detection ($S/N > 3$; left), a marginal detection ($S/N \approx 3$; middle), and a non-detection ($S/N < 3$; right) in the 140 μm band. All panels are $16' \times 16'$. Red circles and white annuli show the photometry and sky apertures, respectively. Colour bars are in units of MJy sr^{-1} .

Table 1. AKARI robust detection ($S/N > 3$) statistics.

Band	Detected	Not detected	Not observed	Total
9 μm	106	152	2	260
18 μm	33	227	0	260
65 μm	42	217	1	260
90 μm	111	148	1	260
140 μm	70	184	6	260

Notes. The 14 and 13 galaxies not observed with AKARI in the 65 and 90 μm bands, respectively, are supplemented by IRAS 60 and/or 100 μm measurements.

have published *Spitzer* 70 μm measurements (Amblard et al. 2014) and 22 galaxies have both *Herschel* 100 and 160 μm measurements (Dale et al. 2012; di Serego Alighieri et al. 2013; Baes et al. 2014). In all cases (AKARI 90 μm versus *Spitzer* 70 μm , AKARI 90 μm versus *Herschel* 100 μm , and AKARI 140 μm versus *Herschel* 160 μm), we find that most measurements are consistent within the uncertainties, and that they are proportional with a slope of approximately unity and a small intrinsic scatter of 0.2 dex, thus confirming the reliability of our measurements. These parameters are estimated using a linear fit with free slope and nul intercept in log-log space, adjusting the intrinsic scatter until the reduced χ^2 is equal to 1 (see Williams et al. 2010).

The number of galaxies robustly detected (defined here as having a signal-to-noise ratio $S/N > 3$) is summarised in Table 1 for each band. Detection rates are 41, 13, 16, 43, and 28% for the 9, 18, 65, 90, and 140 μm bands, respectively. In the FIR, 117 galaxies (45%) are detected in at least one band (thus one, two, or three FIR bands), while 71 galaxies (27%) are detected in at least two bands (thus two or three FIR bands). The lower detection rates at 18 and 65 μm are due to a relatively high background level (Kondo et al. 2016) and a narrow bandwidth, respectively (Kawada et al. 2007). Systematic flux density uncertainties are estimated to be 10% in the MIR (9 and 18 μm ; Ishihara et al., in prep.), and 20, 20, and 50% in the FIR (65, 90, and 140 μm , respectively; Takita et al. 2015). For illustrative purposes, Fig. 1 shows an example of a strong detection ($S/N > 3$), a marginal detection ($S/N \approx 3$) and a non-detection ($S/N < 3$), all in the AKARI 140 μm band.

2.3. WISE survey

Near-infrared (NIR) and MIR flux densities for our sample galaxies are also available from the AllWISE catalogue

(Cutri et al. 2013), which is composed of data obtained during the cryogenic and post-cryogenic phases of the WISE all-sky survey. We therefore used the four WISE photometric bands with central wavelengths of 3.4, 4.6, 12, and 22 μm . Total magnitudes were measured with aperture photometry (and are referred to as WXGMAG, with X equal to 1, 2, 3, or 4 for each of the four WISE bands) with the aperture calculated from 2MASS NIR surface photometry (Skrutskie et al. 2006) and the WISE PSF. When a WXGMAG magnitude is not available, we adopted instead the profile fit magnitude WXMPRO. However, as some galaxies are much more spatially extended than the WISE PSF, the profile fit photometry can underestimate the true total fluxes. To avoid this, the WXMPRO magnitudes were calibrated using the method of Griffith et al. (2015), which takes into account the extent of the galaxies as measured from other WISE photometric parameters. Despite this, we used the uncorrected profile fit magnitudes when there is strong contamination from background sources, as the correction process is then likely to be inaccurate. The 2MASS-determined WXGMAG apertures of galaxies that are resolved well spatially can also be slightly too small, resulting in total flux densities that are underestimated by as much as 30%². We therefore add a systematic uncertainty of 30% to the WISE systematic flux calibration uncertainties.

3. Results

3.1. Relation between infrared and K_s -band luminosities

Figure 2 shows correlations between the total 9, 18, 90, and 140 μm AKARI luminosities and the total K_s -band luminosities listed in Cappellari et al. (2011). Luminosities are estimated using the galaxy distances listed in Cappellari et al. (2011) throughout this paper. Data points are colour-coded according to whether the sample galaxies are detected in CO (blue) or not (red) in Young et al. (2011). To quantify the contribution of the stellar emission from old stellar populations to the AKARI luminosities, we fitted the correlations of non-CO-detected galaxies with straight lines. The best fits are shown in the panels of Fig. 2 and the best-fit parameters are listed in Table 2. By subtracting the best fits from the luminosities of CO-detected galaxies, we can estimate their excess luminosities and assess whether these correlate with the K_s -band luminosities. This in turn establishes if the excess luminosities are of (circum)stellar origin or not, and thus of interstellar origin.

² http://wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec6_3e.html

Fig. 2. Total 9, 18, 90, and 140 μm luminosities vs. total K_s -band luminosities for IR measurements with $S/N > 2.4, 2.2, 2.7$, and 2.8 , respectively (solid circles). Conversely, open triangles indicate $2.4, 2.2, 2.7$, and 2.8σ upper limits, respectively. Blue and red data points denote CO-detected and non-CO-detected galaxies, respectively. Linear correlation coefficients (R) and p -values for CO-detected and non-CO-detected galaxies are indicated in blue and red, respectively, for galaxies above the stated S/N thresholds. Solid black lines show the best linear fits to the non-CO-detected galaxies only, excluding upper limits (see Table 2). The *bottom four panels* are the same as the *top four panels*, but without upper limits.

As the sample galaxies cover a rather large range of K_s -band luminosities and are spread over that range roughly uniformly in $\log(L_{K_s}/L_{\odot})$, it is preferable to do the above fits in log-log space (as shown in Fig. 2). While we would ideally use only robustly detected galaxies for those fits, i.e. those measurements with $S/N > 3$, this would not leave enough data points for a reliable fit at 18 μm . For each band, we therefore use the lowest S/N threshold yielding only positive measurements ($S/N > 2.4, 2.2, 2.7$, and 2.8 at 9, 18, 90 and 140 μm , respectively). The linear correlation coefficients (R) of those measurements and the

probabilities of obtaining the measured R if the null hypothesis is true (p) are also listed in each panel to ascertain the strengths of the correlations. Measurements below those S/N thresholds are replaced by upper limits of the same significance in Fig. 2.

As can be seen in the top left panel of Fig. 2, the 9 μm luminosities of non-CO-detected galaxies correlate very well with their K_s -band luminosities with a correlation coefficient $R = 0.78$ and $>99\%$ confidence levels. As K_s band traces old stellar populations and the 9 μm emission of non-CO-detected galaxies is also expected to be dominated by emission from

Table 2. Parameters of the best linear fits in Fig. 2.

Band	a	b
9 μm	0.60 ± 0.06	35.24 ± 0.64
18 μm	0.32 ± 0.20	38.18 ± 2.12
90 μm	0.33 ± 0.04	38.24 ± 0.44
140 μm	0.36 ± 0.09	37.77 ± 1.00

Notes. Data points are fit with $\log(L_{\text{IR}}/\text{erg s}^{-1}) = a \log(L_K/L_\odot) + b$.

the stars themselves, a correlation between these two bands is expected. However, CO-detected galaxies show excess 9 μm emission, which is systematically above the correlation of non-CO-detected galaxies (or consistent with it), suggesting that CO-detected galaxies have PAH emission beyond any associated with the stars. Indeed, the AKARI 9 μm band is sensitive to major PAH bands at 6.2, 7.7 and 8.6 μm (Ishihara et al. 2010). Furthermore, the excess luminosities of CO-detected galaxies do not correlate well with their K_s -band luminosities ($R = -0.14$ and $p = 0.36$), suggesting that their PAHs are not of circumstellar origin but rather of interstellar origin.

The correlation between the 18 μm and K_s -band luminosities is also significant for non-CO-detected galaxies ($R = 0.73$ and $p < 0.01$; top right panel of Fig. 2), suggesting that the bulk of their 18 μm emission is of circumstellar dust origin. This is supported by the fact that circumstellar dust generated and heated by old stars is known to be the dominant emission source in ETGs at 15 and 24 μm (Athey et al. 2002; Temi et al. 2009). Most CO-detected galaxies again show a significant excess above the correlation of non-CO-detected galaxies and their excess luminosities are not correlated with their K_s -band luminosities ($R = -0.18$ and $p = 0.32$). The 18 μm emission of CO-detected galaxies is thus likely due to interstellar dust heated by relatively young stellar populations or AGN activity (see Nyland et al. 2016, for a study of nuclear radio emission in ATLAS^{3D} ETGs). The 9 and 18 μm luminosities thus strongly suggest that ETGs with detectable molecular gas also contain significant interstellar dust.

In the bottom two panels of Fig. 2, the correlations between the FIR 90 and 140 μm luminosities (tracing cold dust) and the NIR K_s -band luminosities (tracing stellar emission) of non-CO-detected galaxies are weaker than those in the MIR bands and are not statistically significant. This appears to be consistent with the results of Temi et al. (2007), who argued that FIR emission in ETGs originates from cold dust of interstellar origin, presumably spread and heated by diffuse starlight and/or hot gas. However, the correlations, $p = 0.01$ and 0.05 at 90 and 140 μm , are not totally negligible either. This raises the interesting possibility that the stellar populations of ETGs may have cold dust of circumstellar origin, perhaps in shells at large stellar-centric radii. This should however be verified with either more accurate or more numerous data. Either way, CO-detected galaxies again show systematically brighter FIR emission that is uncorrelated with stellar emission, implying that these galaxies are even richer in interstellar cold dust than the norm (i.e. than non-CO-detected galaxies).

3.2. PAH and dust emission

To estimate accurate PAH and dust luminosities for our sample galaxies, we created spectral energy distributions (SEDs) by combining the 2MASS K_s band, WISE, and AKARI data. We fitted each SED with a model composed of emission from

stars, PAHs, and two dust components (warm and cold). We described the stellar continuum emission with a power-law model. In addition, to describe a silicate feature seen in ETGs around 10 μm (e.g. Bressan et al. 2006), we added a Gaussian function to the power-law model, where the width and amplitude of the Gaussian relative to the stellar continuum were determined from the quiescent elliptical galaxy template of Kaneda et al. (2008). The Draine & Li (2007) model, for lack of a better model, was used for the PAH emission with a size distribution and ionised fraction typical of the diffuse ISM of star-forming galaxies, while only the amplitude was allowed to vary. The warm and cold dust components were each described by a modified black-body model with emissivity power-law index 2 (Galametz et al. 2012), while the amplitude and temperature were allowed to vary. When fitting the SEDs, we used all detections regardless of their significance, adopting their errors as weights ($1/\sigma^2$, where σ is the error), with the additional constraint that the fits must be positive at all wavelengths.

First, we fitted the SEDs of galaxies robustly detected (i.e. $S/N > 3$) in two or three FIR bands, by allowing all the parameters to vary. Then, by fixing the warm and cold dust temperatures to the means of the best-fit temperatures of those galaxies, we fitted the SEDs of the remaining galaxies, i.e. galaxies detected in only one or no FIR band. Although this ignores the differences between random and systematic uncertainties and is therefore not ideal, we added the measurement and systematic flux calibration uncertainties in quadrature when performing the fits.

In our sample, 71 galaxies are robustly detected in two or three FIR bands from which we estimated a mean dust temperature of 83 ± 22 K for the warm component and 26 ± 6 K for the cold component. The fit was not acceptable at the 90% confidence level for 3 of these objects. For the remaining galaxies, the fit was not acceptable for 26 objects. These 29 objects were thus excluded from the following analysis. The SEDs and best-fit models of the 231 remaining ATLAS^{3D} ETGs are shown in Fig. 3.

We calculated the PAH and dust luminosities (L_{PAH} , L_{warm} , and L_{cold}) by integrating the aforementioned best fits of each component over the wavelength range 5–1000 μm . The luminosities thus derived are listed in Table A.2 and the total IR (TIR) luminosities (L_{TIR}) were estimated by simply taking the sums of those three components. To check the reliability of our PAH luminosities, we compared them to the PAH luminosities derived by Shapiro et al. (2010) using the non-stellar *Spitzer* 8 μm emission (as in Sect. 2.2 for our 90 and 140 μm flux densities). The PAH luminosities are almost all consistent within the uncertainties and are proportional with a slope of approximately unity and a small intrinsic scatter of 0.2 dex. Figure 4 shows L_{PAH} , L_{warm} , L_{cold} , and L_{TIR} plotted against H_2 mass; the latter is calculated from the integrated CO line intensity assuming a Galactic conversion factor (see Young et al. 2011). It is clear that the IR luminosities of CO-detected galaxies (here stellar emission-subtracted by construction) are well correlated with their molecular gas masses, thus confirming a tight connection between dust and molecular gas even in ETGs (see also Combes et al. 2007). Among the IR luminosities, L_{warm} has a relatively large scatter, suggesting that dust heating by young stellar populations and/or AGN can vary from galaxy to galaxy.

3.3. Star formation rates

To estimate the current SFRs of the 231 ATLAS^{3D} ETGs with good SED fits, we used the PAH and TIR luminosities calculated from those fits. In particular, ionised PAHs are known

Fig. 3. Observed spectral energy distributions (red data points) overlaid with the best-fit spectral models (solid black lines) for the 231 successfully fitted ATLAS^{3D} galaxies. AKARI data points are shown as stars; other data points are shown as filled circles. Dotted orange, green, red, and blue lines indicate the best-fit stellar, PAH, warm, and cold dust component, respectively. The name of the galaxy is indicated in the top left corner of each panel, in blue for CO-detected galaxies and red for non-CO-detected galaxies. Galaxies with no AKARI FIR (65, 90 or 140 μm) detection are marked with an asterisk. The full figure is available in Appendix B.

Fig. 4. Infrared-derived luminosities (PAH, warm dust, cold dust, and TIR) vs. molecular gas (H_2) masses, for the 231 successfully fitted ATLAS^{3D} galaxies. Blue data points represent CO-detected galaxies while open red triangles show non-CO-detected galaxies (i.e. M_{H_2} upper limits).

to be good tracers of star formation, as they are exposed to the radiation fields of photodissociation regions around relatively young stars and the AKARI 9 μm band is sensitive to the 6.2, 7.7, and 8.6 μm features of ionised PAHs (Ishihara et al. 2010). Relatively quiescent ETGs tend to show unusually high PAH 11.3 μm /PAH 7.7 μm ratios, indicating a dominance of neutral PAHs not related to star formation (e.g. Kaneda et al. 2005, 2008; Panuzzo et al. 2011), but our results are not likely to be sensitive to this unusual interband ratio as L_{PAH} is mostly determined from the AKARI 9 μm band that excludes the 11.3 μm feature. Furthermore, the WISE 12 μm -band fluxes do not indicate the presence of unusually strong PAH 11.3 μm features. To convert L_{PAH} to a SFR, we adopted the method described in Shipley et al. (2016), in which the sum of the 6.2, 7.7, and 11.3 μm features is used to estimate the SFR. The ratio of these PAH bands to the total PAH emission is 0.65 in the PAH template adopted for our SED fits (a value typical of star-forming galaxies; Smith et al. 2007), so we simply propagate this fraction in our calculations. To convert L_{TIR} to a SFR, we used the

conversion of Kennicutt (1998) with a correction to the Kroupa initial mass function (Hao et al. 2011; Murphy et al. 2011).

For the majority of our 231 ETGs, the current SFR is estimated to be in the range $0.01\text{--}1 M_{\odot} \text{ yr}^{-1}$. Furthermore, as shown in the right panel of Fig. 5, the SFRs estimated from PAH luminosities are in good agreement with those estimated from TIR luminosities with an average ratio of $SFR_{\text{PAH}}/SFR_{\text{TIR}} = 1.0 \pm 0.1$ and nul intrinsic scatter (given the large uncertainties; estimated again as in Sect. 2.2).

For 56 CO-detected ETGs of the ATLAS^{3D} sample, Davis et al. (2014) estimated the current SFR with a combination of FUV and 22 μm emission. In the left and middle panels of Fig. 5, we therefore compare those SFRs with the PAH and TIR SFRs calculated here. Our SFRs are generally in good agreement with those of Davis et al. (2014), but they are systematically larger by a factor of ≈ 2 at SFRs smaller than $\approx 0.1 M_{\odot} \text{ yr}^{-1}$; $SFR_{\text{PAH}}/SFR_{\text{FUV}+22 \mu\text{m}} = 1.6 \pm 0.2$ and $SFR_{\text{TIR}}/SFR_{\text{FUV}+22 \mu\text{m}} = 2.2 \pm 0.3$, with intrinsic scatters of 0.3 dex, for all galaxies in common. This systematic difference is presumably due to the specific

Fig. 5. Comparisons of our PAH- and TIR-derived star formation rates and the FUV+22 μm star formation rates of Davis et al. (2014), the latter for CO-detected galaxies only. Solid red lines show the best-fit linear relations with nul intercepts, while the labels list the best-fit slopes, fixed intercepts, and intrinsic scatters around the best-fit relations.

Fig. 6. Comparisons of our PAH- and TIR-derived star formation rates and the FUV+22 μm star formation rates of Davis et al. (2014) with 1.4 GHz star formation rates derived from the measurements of Nyland et al. (2017) for all galaxies in common. Solid red lines show the best-fit linear relations with nul intercepts, while the labels list the best-fit slopes, fixed intercepts, and intrinsic scatters around the best-fit relations.

physical conditions in the star formation regions of ETGs, as discussed in Sect. 4.3.

Low-frequency (1.4 GHz) radio continuum observations of 72 ATLAS^{3D} ETGs were presented by Nyland et al. (2017). We therefore estimated SFRs from these measurements using the conversion of Murphy et al. (2011) and we compared these estimates with our PAH- and TIR-derived estimates in Fig. 6. As shown in the left and middle panels, our measurements are generally in good agreement with those derived from Nyland et al. (2017), but they are systematically larger by factors of $SFR_{\text{PAH}}/SFR_{1.4\text{ GHz}} = 1.4 \pm 0.3$ and $SFR_{\text{TIR}}/SFR_{1.4\text{ GHz}} = 1.5 \pm 0.3$, with intrinsic scatters of 0.5 dex (for all galaxies in common). As can be expected from the discussion in the paragraph above, the 1.4 GHz- and FUV+22 μm -derived SFRs are then in rough agreement; $SFR_{\text{FUV+22 } \mu\text{m}}/SFR_{1.4\text{ GHz}} = 0.8 \pm 0.2$, with an intrinsic scatter of 0.5 dex for galaxies in common (see right panel of Fig. 6). These results are also discussed in Sect. 4.3.

4. Discussion

4.1. Relations between star formation rates and gas masses

Star formation in galaxies is characterised by a power-law relation between the current SFR (Σ_{SFR}) and cold gas mass (Σ_{gas})

surface densities, known as the Kennicutt-Schmidt (KS) law ($\Sigma_{\text{SFR}} \propto \Sigma_{\text{gas}}^n$), where the power-law index n is found to be ≈ 1.4 for local star-forming galaxies (Kennicutt 1998) but varies from 1 to 2 from galaxy to galaxy, reflecting differences in the star formation processes (e.g. Taniguchi & Ohyama 1998; Misiriotis et al. 2006). The power-law index is also generally closer to unity for molecules tracing gas that is denser than CO (e.g. HCN; Gao & Solomon 2004). Davis et al. (2014) investigated the KS law of 56 CO-detected ATLAS^{3D} galaxies using their SFRs estimated from FUV and 22 μm emission. Here, we revisit the KS law for the same 56 ETGs using our SFRs estimated from PAH and TIR emission.

To calculate Σ_{SFR} and Σ_{gas} , we use our own SFRs but we use the gas masses and source sizes listed in Davis et al. (2014), in which the gas masses were derived by summing the CO and central H I gas masses, and the sizes were measured using interferometric CO, spatially resolved MIR, optical, or FUV observations. The resulting $\Sigma_{\text{SFR}} - \Sigma_{\text{gas}}$ correlations are shown in Fig. 7. The solid black lines and shaded grey regions show the KS law of local star-forming galaxies with $n = 1.4$ and its intrinsic scatter, respectively (Kennicutt 1998). The solid and dashed red lines show the best linear fits to the data with free and fixed ($n = 1.4$) slopes, respectively. The best-fit parameters are listed in Table 3. The galaxy NGC 1266, which is systematically located in the top right of each panel of Fig. 7, is

Fig. 7. Star formation rates (PAH- and TIR-derived) vs. total gas surface densities (i.e. KS law) for CO-detected galaxies. Solid black lines and shaded grey regions show the Kennicutt (1998) relation for local star-forming galaxies (with power-law index $n = 1.4$) and its intrinsic scatter, respectively. Solid and dashed red lines show the best linear fits with free and fixed ($n = 1.4$) slope, respectively. The galaxy located in the top right of each panel is NGC 1266, which is known to have strongly suppressed star formation. It was excluded from the fits.

Table 3. Parameters of the best linear fits in Fig. 7.

SFR tracer	n	c
PAH	1.10 ± 0.11	-3.19 ± 0.26
PAH	1.40 (fixed)	-3.81 ± 0.04
Total IR	1.49 ± 0.13	-3.87 ± 0.27
Total IR	1.40 (fixed)	-3.70 ± 0.03

Notes. Data points are fit with $\log(\Sigma_{\text{SFR}}/M_{\odot} \text{ yr}^{-1} \text{ kpc}^{-2}) = n \log(\Sigma_{\text{gas}}/M_{\odot} \text{ pc}^{-2}) + c$.

known to have strongly suppressed star formation and thus to be an outlier in the star formation relation (see Alatalo et al. 2011, 2015; Nyland et al. 2013). We have thus excluded it from the fits. Figure 7 shows that the majority of CO-detected and thus potentially star-forming ETGs follow the KS law of local star-forming galaxies. In particular, the fixed-slope fits have no offset with respect to the Kennicutt (1998) relation, suggesting that the SFEs of local ETGs are similar to those of local star-forming galaxies. This is contrary to the results of Davis et al. (2014), which suggested smaller SFEs for the same sample galaxies by a factor of 2–3. This difference can be directly attributed to the similarly higher SFRs calculated here from the AKARI data (see Sect. 3.3 and Figs. 5 and 6). We come back to this difference in Sect. 4.3.

When left free, the slopes of the power-law fits are $n = 1.10 \pm 0.11$ and $n = 1.49 \pm 0.13$ for the PAH and TIR SFRs, respectively. The significant deviation of the PAH SFR slope from $n = 1.4$ appears to be caused by several galaxies with relatively high Σ_{SFR} at $\Sigma_{\text{gas}} \lesssim 0.6 \times 10^2 M_{\odot} \text{ pc}^{-2}$. Those galaxies may have a different star formation mode (e.g. widespread versus circumnuclear) or a different ISM-acquisition mode (e.g. internal versus external). The origin of the gas can be constrained by examining the kinematic misalignment between stars and gas. Kinematically misaligned gas likely indicates an external origin, such as a minor merger or accretion from filaments; however, kinematically aligned gas is expected from both internal – for example stellar mass loss or a remnant from the galaxy formation event – and occasionally external gas. Figure 8 is analogous to Fig. 7, but we colour code the galaxies according to

their star-ionised gas kinematic (mis)alignment, when such a measurement is available. Davis et al. (2011) measured star-gas kinematic (mis)alignments for 35 CO-detected galaxies mapped interferometrically in CO, but 51 CO-detected galaxies mapped with optical integral-field spectroscopy in ionised gas, and they showed that both measurements are always in agreement. We therefore use the latter measurements here. Interestingly, Fig. 8 reveals that many of the galaxies with relatively high Σ_{SFR} at $\Sigma_{\text{gas}} \lesssim 0.6 \times 10^2 M_{\odot} \text{ pc}^{-2}$, and none of the galaxies with relatively low Σ_{SFR} at those same Σ_{gas} , have kinematically misaligned gas, which indicates that they have acquired their ISM from external sources. Galaxies with kinematically misaligned gas also seem to have higher scatters around the best-fit relations than galaxies with kinematically aligned gas, perhaps suggesting a more bursty and thus temporally variable recent star formation history.

4.2. Relations between star formation rates and stellar masses

In Fig. 9, the PAH and TIR SFRs of our sample galaxies are plotted against their stellar masses $M_{\star}$, the latter are calculated from optical photometry and stellar mass-to-light ratios measured from dynamical models (Cappellari et al. 2013). The data points are also colour-coded according to the mass-weighted stellar population age of each galaxy, obtained by fitting stellar population synthesis models to the optical spectrum of the inner effective radius (McDermid et al. 2015). We use mass-weighted ages rather than the more common luminosity-weighted ages as the former better represent the age of the bulk of the stellar populations because they are less affected by a sprinkling of young stars onto a dominant old stellar population. The dotted black lines show the so-called star formation main sequence, i.e. the correlation between current SFR and stellar mass of local star-forming galaxies (Elbaz et al. 2007). The dotted blue, green, and red lines are linear fits to our ETG galaxies in the age range 3–7, 7–11, and 11–14 Gyr, respectively. The best-fit parameters are listed in Table 4. A similar figure for the SAURON sample of 48 ETGs was presented by Shapiro et al. (2010), but the much larger ATLAS^{3D} sample of 260 ETGs studied here (231 with relevant measurements) offers much clearer insight into the

Fig. 8. Same as Fig. 7, but with galaxies with kinematically aligned and misaligned stars and ionised gas shown in red and blue, respectively.

Fig. 9. Correlations between the star formation rates (PAH- and TIR-derived) and stellar masses of the 231 successfully fitted ATLAS^{3D} galaxies. Data points are colour coded according to their mass-weighted stellar population age (McDermid et al. 2015). Dotted black lines show the star formation main sequence of local star-forming galaxies (Elbaz et al. 2007). Dotted blue, green, and red lines show the best linear fits for the age range 3–7, 7–11, and 11–14 Gyr, respectively.

relationship between current SFR, stellar mass and stellar population age.

Figure 9 shows that, at fixed stellar mass, all our sample ETGs have a lower current SFR than that of local star-forming galaxies, confirming that local ETGs are quiescent galaxies. Figure 9 also shows that, overall and at least in the recent history of the universe, the SFRs of ETGs must decrease as they evolve; i.e. ETGs move to the lower right of the panels as they become older and more massive. However, while at fixed mass the current SFRs decrease strongly with age (here by about 1.5 dex), at fixed stellar age the current SFRs increase with stellar mass. In fact, at fixed stellar age the SFRs and stellar masses of our ETGs are correlated similarly to those of local star-forming galaxies with power-law slopes near unity (see Table 4). This is shown

more clearly in Fig. 10, which shows the specific SFRs (sSFRs; i.e. SFR/M_*) of our sample galaxies as a function of stellar mass. Indeed, while the current sSFRs of our ETGs strongly decrease with age as expected from Fig. 9, they are nearly independent of stellar mass at any age. Similar trends are reported for galaxies with low SFRs by Saintonge et al. (2016), who studied both early- and late-type galaxies (see their Figs. 2 and 4). This suggests that local ETGs acquire their cold ISM necessary to form stars by mechanisms related to stellar mass, as do normal star-forming galaxies (e.g. Davé et al. 2011).

The sSFRs and stellar ages we discuss are independent of each other and are not correlated by construction. As our SFRs, estimated from MIR photometry, trace only young stars while our total stellar masses, estimated from optical photometry and

Fig. 10. Same as Fig. 9, but for the specific star formation rates.

Table 4. Parameters of the best linear fits in Fig. 9.

SFR tracer	Mass-weighted age (Gyr)	a	b
PAH	3–17	0.93 ± 0.23	-10.12 ± 2.33
PAH	7–11	0.72 ± 0.20	-8.32 ± 2.10
PAH	11–14	1.09 ± 0.22	-12.94 ± 2.43
Total IR	3–7	0.80 ± 0.17	-8.82 ± 1.71
Total IR	7–11	0.76 ± 0.13	-8.95 ± 1.37
Total IR	11–14	0.84 ± 0.09	-10.32 ± 1.04

Notes. Data points are fit with $\log(SFR/M_{\odot} \text{ yr}^{-1}) = a \log(M_{\star}/M_{\odot}) + b$.

stellar dynamical modelling, include both young and old stars, our sSFRs trace the ratio of young to both young and old stars. On the other hand, our stellar ages, estimated from optical spectroscopy, only trace the ratio of young to old stars. Our SFRs are also (nearly) instantaneous measures tracing stars of ages typically <100 Myr, while our stellar ages are also affected by, and nearly always degenerate with, intermediate age stars (≥ 1 Gyr).

4.3. Star formation in early-type galaxies

Based on current SFRs estimated from FUV and $22 \mu\text{m}$ emission, Davis et al. (2014) argued that local ETGs have SFEs lower than those of local star-forming galaxies; this is an effect they assigned to the particular dynamical properties of ETGs, such as increased central disc stability and/or galactic shear in the central regions where molecular gas is found. However, our results show that the SFEs of (the same) local ETGs estimated from AKARI PAH and TIR emission are similar to those of local star-forming galaxies (see Figs. 5 and 7), which is in agreement with the smaller study of Shapiro et al. (2010) using *Spitzer* PAH emission. As TIR emission can be enhanced by low-luminosity AGN and old stellar populations, which are unrelated to star formation, the discrepancy of the TIR-estimated SFRs is likely easily explained. The discrepancy of the PAH-estimated SFRs is however not so easily explained and may be due to the fact

that PAH emission (like TIR emission) can trace star formation regions with softer UV radiation fields than those traced in the FUV and at $22 \mu\text{m}$ (e.g. Compiègne et al. 2011). The higher PAH SFRs therefore apparently call for less massive star formation. Indeed, it is suggested that galaxies with low SFRs preferentially form low-mass stars rather than high-mass stars (e.g. Hoversten & Glazebrook 2008; Gunawardhana et al. 2011), which would result in softer radiation fields in ETGs. The ratios of the [C II] $158 \mu\text{m}$ line to FIR fluxes also support radiation fields that are softer in ETGs than in spiral galaxies (Malhotra et al. 2000). While old stars in ETGs can and do emit in the UV (UV-upturn phenomenon; Yi et al. 1997), Davis et al. (2014) argued that this does not significantly affect the FUV-based SFRs of the ATLAS^{3D} ETGs. Interestingly, this preference for low-mass stars is consistent with a flurry of recent works arguing that ETGs have bottom-heavy initial mass functions (IMFs; see e.g. van Dokkum & Conroy 2010; Cappellari et al. 2012).

Of course, just like the FUV and $22 \mu\text{m}$ estimates, the 1.4 GHz SFR estimates derived from the Nyland et al. (2017) radio continuum measurements are also systematically lower than the PAH- and TIR-derived estimates (see Fig. 6). As the 1.4 GHz continuum emission is due to non-thermal synchrotron emission associated with supernova remnants, and thus ultimately the explosions of massive stars (e.g. Murphy et al. 2011), this trend is

Fig. 11. Star formation efficiencies (PAH- and TIR-derived) vs. stellar masses for CO-detected galaxies. Data points are colour-coded according to their mass-weighted stellar population age (McDermid et al. 2015), as in Fig. 9.

Fig. 12. Cold gas fraction vs. mass-weighted stellar population age (McDermid et al. 2015) for CO-detected galaxies. Data points are colour coded according to their PAH-derived specific star formation rates.

also consistent with a scenario whereby massive star formation is inefficient in ETGs.

Figure 11 shows the current SFEs of CO-detected ETGs as a function of their stellar masses, with the data points colour coded as a function of mass-weighted stellar age. No dependence is apparent as a function of either stellar mass or age. Combined with the continuous decrease of the $sSFR - M_\star$ relations with stellar age seen in Fig. 10, this implies that the current cold gas fraction ($M_{\text{gas}}/M_\star$) of ETGs must decrease with stellar age (at fixed stellar mass; $sSFR \equiv SFR/M_\star = SFE \times M_{\text{gas}}/M_\star$). We show this trend in Fig. 12, where $M_{\text{gas}}/M_\star$ is plotted as a function of

mass-weighted stellar age. The same trend is reported for nearby massive galaxies ($\log(M_\star/M_\odot) > 10$) by Saintonge et al. (2011, 2016), although our study extends the trend to lower gas fractions ($M_{\text{gas}}/M_\star \approx 10^{-4}$). Hence our results suggest that the decrease of the current SFR in local ETGs is likely due to a decrease of their cold gas fractions, rather than a suppression of star formation via for example AGN feedback or specific dynamical properties.

5. Conclusions

We have conducted a systematic study of star formation in the 260 local ETGs of the ATLAS^{3D} survey, using newly measured IR fluxes from the AKARI all-sky diffuse maps combined with WISE and 2MASS literature data. In the AKARI FIR bands, we detected 117 (45%) galaxies in at least one band, while we detected 71 (27%) galaxies in at least two bands. The 9 and 18 μm luminosities of the non-CO-detected galaxies are correlated with the stellar luminosities, showing that they trace stellar and circumstellar dust emission, respectively. On the other hand, CO-detected galaxies show an excess above these correlations, which are uncorrelated with the stellar luminosities, indicating that they likely contain PAHs and dust of interstellar origin. There are, at best, weak correlations between the 90 and 140 μm luminosities and the stellar luminosities of non-CO-detected galaxies (but again an excess for CO-detected galaxies), suggesting that FIR emission in ETGs primarily originates from cold dust unrelated to the stars.

We estimated the IR luminosities (L_{PAH} , L_{warm} , L_{cold} , and L_{TIR}) of the sample ETGs by decomposing their SEDs with a dust model. For the CO-detected galaxies, all of the IR luminosities correlate well with the H_2 masses, confirming a tight connection between interstellar dust and molecular gas in local ETGs. Using L_{PAH} and L_{TIR} as current SFR indicators, we measure typical current SFRs of $0.01\text{--}1 M_\odot \text{ yr}^{-1}$. These SFRs are generally in good agreement with previously measured SFRs using FUV and 22 μm emission and 1.4 GHz radio continuum emission, but

they are systematically higher by a factor of ≈ 1.5 –2, particularly at low SFRs. This discrepancy may be because PAH and TIR emission can trace star formation regions with softer radiation fields than those traced in the FUV, 22 μ m, and 1.4 GHz bands. The majority of ETGs appear to follow the standard KS law of local star-forming galaxies, with no offset, indicating that they have similar current SFEs. This is contrary to recent results suggesting slightly lower SFEs and is directly related to the higher SFRs derived. There is also some evidence that ETGs whose cold gas has an external origin have more varied SFEs.

We have also investigated the relations between current SFRs, stellar masses, and mass-weighted stellar population ages. At fixed stellar mass, the SFRs rapidly decrease with age, but at fixed stellar age the SFRs are roughly linearly correlated with stellar mass, indicating roughly constant sSFRs. In addition, the current SFEs of CO-detected galaxies appear independent of both stellar age and mass. These results suggest that local ETGs acquire their cold ISM by mechanisms regulated primarily by stellar mass, while at fixed stellar mass the cold gas fraction must decrease with stellar age. Hence the current relatively low SFRs of local ETGs are likely due to a decrease of their cold gas fractions, rather than a suppression of star formation.

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Appendix A: AKARI-measured infrared fluxes of all ATLAS^{3D} galaxies and infrared luminosities derived from SED fitting

Table A.1. AKARI-measured infrared fluxes of all ATLAS^{3D} galaxies.

Galaxy	9 μm (mJy)	18 μm (mJy)	65 μm (mJy)	90 μm (mJy)	140 μm (mJy)
IC 0560	22.09 $\pm$ 7.24	-2.74 $\pm$ 14.81	126.86 $\pm$ 287.93	300.85 $\pm$ 92.04	919.98 $\pm$ 353.35
IC 0598	16.27 $\pm$ 5.93	4.54 $\pm$ 10.00	... ^b	239.78 $\pm$ 52.23	201.10 $\pm$ 71.05
IC 0676	155.91 $\pm$ 12.00	411.10 $\pm$ 24.43	2258.15 $\pm$ 263.38	3393.55 $\pm$ 63.18	2304.91 $\pm$ 77.22
IC 0719	91.47 $\pm$ 7.36	51.06 $\pm$ 11.60	813.76 $\pm$ 252.97	2046.74 $\pm$ 56.34	2123.08 $\pm$ 285.24
IC 0782	1.53 $\pm$ 14.34	5.56 $\pm$ 17.69	... ^b	318.52 $\pm$ 60.95	-188.17 $\pm$ 196.01
IC 1024	178.18 $\pm$ 6.49	250.94 $\pm$ 13.47	2126.95 $\pm$ 251.55	5800.14 $\pm$ 82.25	7864.90 $\pm$ 183.53
IC 3631	2.84 $\pm$ 9.25	-6.92 $\pm$ 14.09	-179.53 $\pm$ 343.00	-24.24 $\pm$ 108.04	-91.55 $\pm$ 75.64
NGC 0448	26.17 $\pm$ 5.64	7.05 $\pm$ 11.66	-498.32 $\pm$ 358.69	19.37 $\pm$ 71.52	... ^b
NGC 0474	-1.21 $\pm$ 15.88	9.53 $\pm$ 27.07	... ^b	2.84 $\pm$ 110.22	333.20 $\pm$ 252.83
NGC 0502	-5.54 $\pm$ 7.61	6.43 $\pm$ 12.95	-88.41 $\pm$ 235.77	10.15 $\pm$ 67.55	... ^b
NGC 0509	1.91 $\pm$ 11.29	4.35 $\pm$ 18.11	... ^b	-28.15 $\pm$ 56.44	86.19 $\pm$ 224.23
NGC 0516	4.89 $\pm$ 7.87	-1.65 $\pm$ 13.02	-94.96 $\pm$ 350.71	249.47 $\pm$ 76.43	-64.69 $\pm$ 303.49
NGC 0524	64.88 $\pm$ 20.75	70.81 $\pm$ 41.79	696.44 $\pm$ 458.18	1851.18 $\pm$ 100.11	3048.60 $\pm$ 352.18
NGC 0525	11.56 $\pm$ 9.05	-5.95 $\pm$ 22.19	-305.74 $\pm$ 440.70	-31.31 $\pm$ 95.30	-1062.66 $\pm$ 588.40
NGC 0661	7.40 $\pm$ 9.08	9.95 $\pm$ 9.67	-111.75 $\pm$ 304.05	380.90 $\pm$ 80.95	-260.70 $\pm$ 190.48
NGC 0680	4.68 $\pm$ 8.38	21.22 $\pm$ 13.66	... ^b	202.88 $\pm$ 82.63	376.06 $\pm$ 220.11
NGC 0770	5.20 $\pm$ 7.36	-10.05 $\pm$ 11.09	... ^b	... ^b	... ^b
NGC 0821	65.18 $\pm$ 14.52	76.42 $\pm$ 23.71	303.32 $\pm$ 240.86	208.02 $\pm$ 87.63	-257.83 $\pm$ 361.71
NGC 0936	55.82 $\pm$ 30.99	-6.19 $\pm$ 51.90	... ^b	435.32 $\pm$ 69.74	-171.50 $\pm$ 137.64
NGC 1023	150.16 $\pm$ 24.37	109.60 $\pm$ 45.00	182.60 $\pm$ 250.56	74.13 $\pm$ 64.71	-77.92 $\pm$ 132.30
NGC 1121	17.73 $\pm$ 6.05	-16.98 $\pm$ 9.58	177.91 $\pm$ 239.43	3.35 $\pm$ 77.73	... ^b
NGC 1222	353.33 $\pm$ 8.04	1064.58 $\pm$ 14.04	11289.63 $\pm$ 344.26	12613.37 $\pm$ 94.35	9493.47 $\pm$ 185.41
NGC 1248	19.65 $\pm$ 10.28	18.16 $\pm$ 15.94	-281.98 $\pm$ 221.96	140.14 $\pm$ 80.13	56.11 $\pm$ 176.81
NGC 1266	84.42 $\pm$ 10.53	333.47 $\pm$ 18.08	11714.22 $\pm$ 393.10	13428.99 $\pm$ 116.75	11092.29 $\pm$ 308.04
NGC 1289	13.39 $\pm$ 8.41	13.35 $\pm$ 24.69	319.36 $\pm$ 305.82	723.11 $\pm$ 90.96	807.54 $\pm$ 192.19
NGC 1665	15.13 $\pm$ 18.88	-15.89 $\pm$ 36.33	... ^b	-169.08 $\pm$ 91.80	-134.52 $\pm$ 296.68
NGC 2481	11.28 $\pm$ 6.91	28.88 $\pm$ 16.13	... ^b	... ^b	... ^b
NGC 2549	60.39 $\pm$ 11.36	33.45 $\pm$ 30.52	... ^b	-13.90 $\pm$ 70.67	-84.19 $\pm$ 253.56
NGC 2577	7.55 $\pm$ 10.62	-19.56 $\pm$ 27.88	160.00 $\pm$ 36.00 ^a	1250.00 $\pm$ 193.00 ^a	... ^a
NGC 2592	29.13 $\pm$ 17.87	37.73 $\pm$ 24.79	-118.57 $\pm$ 548.53	-67.72 $\pm$ 89.59	-84.68 $\pm$ 296.58
NGC 2594	... ^a	-25.05 $\pm$ 13.64	-340.62 $\pm$ 191.10	-95.55 $\pm$ 44.75	-85.23 $\pm$ 171.77
NGC 2679	15.89 $\pm$ 11.67	23.98 $\pm$ 27.67	-24.28 $\pm$ 234.12	208.46 $\pm$ 60.79	181.79 $\pm$ 136.02
NGC 2685	66.02 $\pm$ 10.20	37.36 $\pm$ 19.71	... ^b	842.64 $\pm$ 42.91	2239.30 $\pm$ 134.75
NGC 2695	-0.83 $\pm$ 9.45	26.57 $\pm$ 15.87	... ^b	-272.73 $\pm$ 108.70	155.48 $\pm$ 156.47
NGC 2698	44.28 $\pm$ 7.84	-23.48 $\pm$ 10.46	... ^b	367.39 $\pm$ 49.86	... ^b
NGC 2699	18.44 $\pm$ 6.91	-3.51 $\pm$ 10.35	79.44 $\pm$ 203.29	71.41 $\pm$ 73.37	54.61 $\pm$ 99.46
NGC 2764	227.43 $\pm$ 7.65	301.78 $\pm$ 26.45	2779.17 $\pm$ 238.58	5762.03 $\pm$ 64.86	6479.78 $\pm$ 288.04
NGC 2768	67.96 $\pm$ 48.13	48.16 $\pm$ 59.93	472.80 $\pm$ 565.93	458.41 $\pm$ 103.67	747.48 $\pm$ 420.77
NGC 2778	20.26 $\pm$ 8.38	16.18 $\pm$ 16.24	-337.31 $\pm$ 147.70	456.60 $\pm$ 71.52	244.53 $\pm$ 115.49
NGC 2824	40.39 $\pm$ 6.58	64.77 $\pm$ 10.75	630.64 $\pm$ 309.26	1564.48 $\pm$ 52.88	1016.50 $\pm$ 152.58
NGC 2852	-4.30 $\pm$ 6.51	2.34 $\pm$ 9.45	-211.10 $\pm$ 210.08	33.60 $\pm$ 53.46	... ^b
NGC 2859	69.67 $\pm$ 11.30	4.21 $\pm$ 20.47	468.12 $\pm$ 226.05	660.07 $\pm$ 54.60	363.20 $\pm$ 142.21
NGC 2880	34.21 $\pm$ 13.46	39.99 $\pm$ 32.41	91.33 $\pm$ 329.26	192.11 $\pm$ 55.95	450.83 $\pm$ 117.29
NGC 2950	58.73 $\pm$ 10.41	-1.27 $\pm$ 15.37	6.39 $\pm$ 204.51	82.08 $\pm$ 39.25	158.41 $\pm$ 86.79
NGC 2962	11.63 $\pm$ 13.54	38.78 $\pm$ 20.52	150.09 $\pm$ 296.85	495.39 $\pm$ 64.40	1671.71 $\pm$ 212.41
NGC 2974	98.46 $\pm$ 25.19	65.77 $\pm$ 37.19	365.99 $\pm$ 330.64	1083.13 $\pm$ 80.70	2380.69 $\pm$ 222.63
NGC 3032	89.03 $\pm$ 12.02	158.63 $\pm$ 15.81	1310.93 $\pm$ 306.98	3533.09 $\pm$ 76.29	1583.76 $\pm$ 82.02
NGC 3073	-7.47 $\pm$ 15.59	-4.61 $\pm$ 23.95	234.57 $\pm$ 196.62	18.41 $\pm$ 52.96	242.43 $\pm$ 121.60
NGC 3098	18.79 $\pm$ 6.83	9.31 $\pm$ 16.04	-128.39 $\pm$ 265.95	-64.67 $\pm$ 72.51	-386.44 $\pm$ 223.06
NGC 3156	17.76 $\pm$ 10.31	37.45 $\pm$ 20.08	150.44 $\pm$ 267.86	446.58 $\pm$ 75.94	736.41 $\pm$ 184.56
NGC 3182	31.22 $\pm$ 8.40	41.56 $\pm$ 16.77	4.97 $\pm$ 150.11	508.17 $\pm$ 45.96	278.92 $\pm$ 77.41

Notes. ^(a) Not observed with AKARI. When possible, the missing 65 and/or 90 μm flux densities are replaced by IRAS 60 and/or 100 μm measurements from NED. ^(b) Measurement likely affected by source confusion or instrumental artefact.

Table A.1. continued.

Galaxy	9 μm (mJy)	18 μm (mJy)	65 μm (mJy)	90 μm (mJy)	140 μm (mJy)
NGC 3193	69.13 $\pm$ 15.99	-3.75 $\pm$ 22.51	-142.28 $\pm$ 232.99	64.48 $\pm$ 69.28	-102.89 $\pm$ 156.10
NGC 3226	41.28 $\pm$ 18.34	2.05 $\pm$ 23.65	... ^b	... ^b	... ^b
NGC 3230	31.58 $\pm$ 11.21	-16.50 $\pm$ 17.92	161.04 $\pm$ 279.60	205.44 $\pm$ 54.95	-212.26 $\pm$ 144.72
NGC 3245	60.19 $\pm$ 13.59	153.32 $\pm$ 22.68	1307.80 $\pm$ 233.28	3225.60 $\pm$ 66.75	1824.74 $\pm$ 142.60
NGC 3248	14.60 $\pm$ 8.83	14.54 $\pm$ 12.84	-356.26 $\pm$ 282.41	-86.67 $\pm$ 58.23	-255.13 $\pm$ 185.92
NGC 3301	66.18 $\pm$ 12.31	21.17 $\pm$ 19.14	497.52 $\pm$ 323.36	758.28 $\pm$ 79.16	1807.68 $\pm$ 242.41
NGC 3377	74.52 $\pm$ 17.41	19.81 $\pm$ 41.84	... ^b	55.47 $\pm$ 69.56	-351.97 $\pm$ 335.52
NGC 3379	113.38 $\pm$ 22.02	48.33 $\pm$ 33.40	-20.99 $\pm$ 295.23	-27.63 $\pm$ 43.46	32.41 $\pm$ 181.01
NGC 3384	112.17 $\pm$ 19.28	53.66 $\pm$ 31.71	262.24 $\pm$ 249.95	-56.07 $\pm$ 61.97	-17.58 $\pm$ 150.51
NGC 3400	2.48 $\pm$ 8.57	-19.03 $\pm$ 14.43	165.24 $\pm$ 188.75	16.50 $\pm$ 51.20	157.89 $\pm$ 136.21
NGC 3412	60.58 $\pm$ 16.48	-8.37 $\pm$ 26.00	... ^b	-43.08 $\pm$ 77.34	-299.67 $\pm$ 166.45
NGC 3414	36.54 $\pm$ 14.76	46.61 $\pm$ 22.24	577.72 $\pm$ 246.21	377.99 $\pm$ 65.90	1207.45 $\pm$ 132.40
NGC 3457	21.76 $\pm$ 6.84	3.63 $\pm$ 12.42	-242.21 $\pm$ 316.92	282.71 $\pm$ 58.22	-113.19 $\pm$ 175.75
NGC 3458	12.22 $\pm$ 8.80	-24.54 $\pm$ 11.20	... ^b	-164.63 $\pm$ 61.82	46.80 $\pm$ 75.84
NGC 3489	120.94 $\pm$ 12.63	86.75 $\pm$ 21.76	1524.15 $\pm$ 300.91	2476.44 $\pm$ 51.32	2195.04 $\pm$ 110.13
NGC 3499	17.24 $\pm$ 6.26	22.20 $\pm$ 9.40	214.99 $\pm$ 235.54	102.62 $\pm$ 39.49	71.53 $\pm$ 48.39
NGC 3522	6.86 $\pm$ 5.46	-16.27 $\pm$ 17.15	-66.55 $\pm$ 304.41	149.33 $\pm$ 65.13	75.15 $\pm$ 121.77
NGC 3530	1.46 $\pm$ 4.78	-1.54 $\pm$ 8.85	171.01 $\pm$ 173.75	199.24 $\pm$ 41.54	-17.45 $\pm$ 60.28
NGC 3595	14.99 $\pm$ 8.34	0.10 $\pm$ 16.07	-302.25 $\pm$ 409.48	461.52 $\pm$ 70.59	83.62 $\pm$ 224.39
NGC 3599	23.76 $\pm$ 11.24	-29.18 $\pm$ 32.74	-212.26 $\pm$ 349.25	407.69 $\pm$ 83.84	507.72 $\pm$ 185.78
NGC 3605	13.94 $\pm$ 9.77	7.36 $\pm$ 18.25	... ^b	... ^b	... ^b
NGC 3607	96.58 $\pm$ 28.11	42.52 $\pm$ 41.27	1970.03 $\pm$ 319.66	2275.15 $\pm$ 93.75	3305.25 $\pm$ 173.40
NGC 3608	62.63 $\pm$ 17.24	24.39 $\pm$ 31.76	304.65 $\pm$ 415.53	24.04 $\pm$ 116.47	-162.39 $\pm$ 263.76
NGC 3610	40.04 $\pm$ 9.17	32.40 $\pm$ 15.23	241.53 $\pm$ 178.56	38.58 $\pm$ 73.09	-329.93 $\pm$ 137.04
NGC 3613	34.39 $\pm$ 10.93	12.75 $\pm$ 17.66	... ^b	... ^b	-75.51 $\pm$ 56.81
NGC 3619	57.08 $\pm$ 13.16	44.70 $\pm$ 23.90	621.67 $\pm$ 208.89	954.24 $\pm$ 45.99	319.44 $\pm$ 45.81
NGC 3626	106.73 $\pm$ 13.16	148.10 $\pm$ 21.51	1427.62 $\pm$ 322.23	3614.93 $\pm$ 76.39	3305.24 $\pm$ 195.69
NGC 3630	29.33 $\pm$ 6.13	18.21 $\pm$ 11.69	-486.17 $\pm$ 385.52	70.68 $\pm$ 94.08	-274.36 $\pm$ 649.14
NGC 3640	75.91 $\pm$ 15.79	39.58 $\pm$ 24.68	0.00 $\pm$ 39.00 ^a	0.00 $\pm$ 66.00 ^a	... ^a
NGC 3641	12.59 $\pm$ 7.15	-7.33 $\pm$ 8.33	0.00 $\pm$ 41.00 ^a	0.00 $\pm$ 145.00 ^a	... ^a
NGC 3648	-2.12 $\pm$ 6.12	-2.77 $\pm$ 11.50	-248.98 $\pm$ 228.09	9.24 $\pm$ 55.83	-51.43 $\pm$ 92.10
NGC 3658	26.84 $\pm$ 9.49	0.20 $\pm$ 17.33	299.10 $\pm$ 270.26	276.90 $\pm$ 64.64	28.78 $\pm$ 81.13
NGC 3665	123.14 $\pm$ 15.34	105.40 $\pm$ 27.61	1424.53 $\pm$ 269.55	3911.87 $\pm$ 53.88	4241.70 $\pm$ 101.93
NGC 3674	10.61 $\pm$ 6.83	12.90 $\pm$ 10.26	... ^b	-60.53 $\pm$ 47.78	51.25 $\pm$ 67.70
NGC 3694	41.11 $\pm$ 13.05	37.53 $\pm$ 21.00	1136.62 $\pm$ 239.63	922.90 $\pm$ 64.88	386.33 $\pm$ 139.64
NGC 3757	12.77 $\pm$ 5.86	-0.20 $\pm$ 14.62	-85.81 $\pm$ 220.38	-48.15 $\pm$ 57.15	33.19 $\pm$ 47.02
NGC 3796	17.76 $\pm$ 8.00	2.28 $\pm$ 11.15	9.40 $\pm$ 145.26	267.71 $\pm$ 54.24	213.67 $\pm$ 44.29
NGC 3838	18.92 $\pm$ 7.00	1.72 $\pm$ 9.53	... ^b	221.68 $\pm$ 44.10	53.72 $\pm$ 96.65
NGC 3941	104.77 $\pm$ 16.53	75.55 $\pm$ 25.82	52.30 $\pm$ 253.93	275.63 $\pm$ 51.25	217.30 $\pm$ 109.59
NGC 3945	34.83 $\pm$ 15.61	49.96 $\pm$ 25.73	759.65 $\pm$ 210.88	727.79 $\pm$ 48.57	602.26 $\pm$ 87.67
NGC 3998	158.19 $\pm$ 11.07	196.59 $\pm$ 19.10	540.99 $\pm$ 186.84	511.96 $\pm$ 43.29	529.14 $\pm$ 71.10
NGC 4026	102.73 $\pm$ 10.62	9.56 $\pm$ 16.61	-242.10 $\pm$ 289.05	24.24 $\pm$ 41.85	... ^b
NGC 4036	58.67 $\pm$ 13.46	58.43 $\pm$ 22.67	990.20 $\pm$ 219.56	751.14 $\pm$ 47.57	192.19 $\pm$ 73.94
NGC 4078	3.59 $\pm$ 6.69	0.32 $\pm$ 10.74	... ^b	177.87 $\pm$ 57.43	146.94 $\pm$ 123.39
NGC 4111	110.46 $\pm$ 7.43	95.14 $\pm$ 12.43	666.39 $\pm$ 227.45	1596.75 $\pm$ 69.31	952.24 $\pm$ 101.19
NGC 4119	55.19 $\pm$ 23.24	46.25 $\pm$ 35.54	-89.93 $\pm$ 325.33	640.81 $\pm$ 60.49	433.68 $\pm$ 229.21
NGC 4143	68.25 $\pm$ 11.27	29.97 $\pm$ 16.41	249.16 $\pm$ 177.77	131.20 $\pm$ 52.08	227.92 $\pm$ 65.53
NGC 4150	51.67 $\pm$ 7.87	65.44 $\pm$ 14.26	1651.55 $\pm$ 215.16	1306.65 $\pm$ 38.94	348.75 $\pm$ 51.03
NGC 4168	14.07 $\pm$ 15.14	45.68 $\pm$ 25.48	-153.50 $\pm$ 394.43	172.51 $\pm$ 79.93	714.11 $\pm$ 238.30
NGC 4179	68.80 $\pm$ 9.65	-23.01 $\pm$ 23.87	3.80 $\pm$ 292.46	-76.40 $\pm$ 90.45	254.45 $\pm$ 286.58
NGC 4191	13.93 $\pm$ 8.99	-7.07 $\pm$ 14.53	-361.04 $\pm$ 874.08	75.75 $\pm$ 98.01	... ^b
NGC 4203	82.20 $\pm$ 18.86	72.01 $\pm$ 34.46	849.43 $\pm$ 263.92	1346.32 $\pm$ 46.51	1185.25 $\pm$ 73.59
NGC 4215	47.60 $\pm$ 11.47	-7.70 $\pm$ 18.29	-212.73 $\pm$ 235.30	4.29 $\pm$ 79.54	-100.01 $\pm$ 210.00
NGC 4233	14.41 $\pm$ 9.43	-0.20 $\pm$ 18.41	190.00 $\pm$ 37.00 ^a	480.00 $\pm$ 87.00 ^a	2031.16 $\pm$ 258.93
NGC 4249	-1.34 $\pm$ 8.28	-0.09 $\pm$ 15.29	... ^b	-10.57 $\pm$ 50.61	-246.35 $\pm$ 113.73
NGC 4251	57.91 $\pm$ 9.93	14.37 $\pm$ 20.35	... ^b	111.36 $\pm$ 50.32	-35.38 $\pm$ 50.96
NGC 4255	16.49 $\pm$ 7.15	21.46 $\pm$ 14.15	300.85 $\pm$ 293.77	47.75 $\pm$ 63.10	-144.40 $\pm$ 206.25
NGC 4259	-5.37 $\pm$ 6.45	6.47 $\pm$ 9.92	-169.37 $\pm$ 307.51	224.63 $\pm$ 112.37	-0.17 $\pm$ 235.95

Table A.1. continued.

Galaxy	9 μ m (mJy)	18 μ m (mJy)	65 μ m (mJy)	90 μ m (mJy)	140 μ m (mJy)
NGC 4261	105.98 $\pm$ 21.02	66.78 $\pm$ 35.63	149.26 $\pm$ 394.04	214.36 $\pm$ 92.00	696.73 $\pm$ 274.96
NGC 4262	26.97 $\pm$ 7.38	-6.45 $\pm$ 12.48	-323.77 $\pm$ 344.51	49.32 $\pm$ 73.96	278.66 $\pm$ 230.65
NGC 4264	-1.36 $\pm$ 8.91	5.19 $\pm$ 17.40	...	190.78 $\pm$ 83.39	387.30 $\pm$ 281.79
NGC 4267	16.00 $\pm$ 17.83	63.01 $\pm$ 34.64	186.13 $\pm$ 327.11	57.24 $\pm$ 89.03	-293.79 $\pm$ 233.19
NGC 4268	9.83 $\pm$ 7.42	-14.31 $\pm$ 22.14	3.26 $\pm$ 274.87	363.61 $\pm$ 80.23	820.50 $\pm$ 260.35
NGC 4270	15.56 $\pm$ 9.50	-12.06 $\pm$ 19.92	-196.08 $\pm$ 233.06	-55.59 $\pm$ 69.06	-99.62 $\pm$ 130.95
NGC 4278	70.88 $\pm$ 12.78	53.70 $\pm$ 22.41	901.94 $\pm$ 185.60	1180.53 $\pm$ 54.73	687.50 $\pm$ 70.36
NGC 4281	77.37 $\pm$ 12.64	52.99 $\pm$ 22.06	-238.97 $\pm$ 278.86	710.34 $\pm$ 94.55	438.75 $\pm$ 178.24
NGC 4283	3.52 $\pm$ 8.11	-12.98 $\pm$ 20.40	-97.64 $\pm$ 191.36	149.70 $\pm$ 57.12	35.86 $\pm$ 88.89
NGC 4324	72.98 $\pm$ 14.69	72.39 $\pm$ 23.69	-134.19 $\pm$ 602.68	371.28 $\pm$ 58.70	1939.36 $\pm$ 133.50
NGC 4339	40.70 $\pm$ 17.95	24.42 $\pm$ 26.30	-100.17 $\pm$ 744.13	184.35 $\pm$ 125.31	-140.08 $\pm$ 304.58
NGC 4340	20.93 $\pm$ 16.19	2.36 $\pm$ 33.60	-177.61 $\pm$ 288.69	167.86 $\pm$ 62.21	5.75 $\pm$ 183.17
NGC 4342	7.35 $\pm$ 4.99	17.11 $\pm$ 10.11	...	-39.71 $\pm$ 59.18	...
NGC 4346	19.07 $\pm$ 9.05	29.31 $\pm$ 15.51	-208.59 $\pm$ 251.51	-39.95 $\pm$ 66.84	...
NGC 4350	73.49 $\pm$ 8.96	44.28 $\pm$ 14.84	967.73 $\pm$ 257.05	753.42 $\pm$ 52.67	599.41 $\pm$ 125.48
NGC 4365	114.88 $\pm$ 26.07	102.10 $\pm$ 41.72	-390.38 $\pm$ 438.28	-40.15 $\pm$ 95.48	147.96 $\pm$ 205.72
NGC 4371	53.24 $\pm$ 19.77	26.15 $\pm$ 27.33	0.00 $\pm$ 47.00 ^a	0.00 $\pm$ 157.00 ^a	-252.57 $\pm$ 268.50
NGC 4374	146.18 $\pm$ 26.27	172.25 $\pm$ 57.86	210.71 $\pm$ 664.13	957.68 $\pm$ 118.95	1084.09 $\pm$ 203.62
NGC 4377	18.92 $\pm$ 7.69	-5.00 $\pm$ 17.09	112.96 $\pm$ 273.77	400.21 $\pm$ 57.06	1423.95 $\pm$ 209.50
NGC 4379	10.42 $\pm$ 10.33	9.21 $\pm$ 23.47	100.12 $\pm$ 361.98	390.55 $\pm$ 89.13	-177.04 $\pm$ 192.01
NGC 4382	152.32 $\pm$ 36.25	131.49 $\pm$ 65.11	-402.94 $\pm$ 516.92	-95.19 $\pm$ 115.62	129.85 $\pm$ 241.12
NGC 4387	29.46 $\pm$ 8.34	-13.23 $\pm$ 18.30	-116.42 $\pm$ 343.65	188.58 $\pm$ 69.54	-325.22 $\pm$ 216.54
NGC 4406	133.30 $\pm$ 42.59	40.16 $\pm$ 66.70	-424.73 $\pm$ 766.37	-175.19 $\pm$ 146.50	...
NGC 4417	43.59 $\pm$ 10.84	34.10 $\pm$ 19.74	-4.33 $\pm$ 277.55	429.78 $\pm$ 82.38	147.98 $\pm$ 174.78
NGC 4425	19.34 $\pm$ 16.63	24.06 $\pm$ 25.21	-493.04 $\pm$ 399.97	-220.22 $\pm$ 122.66	-862.69 $\pm$ 327.92
NGC 4429	152.51 $\pm$ 23.54	151.71 $\pm$ 34.28	1873.01 $\pm$ 562.37	3467.62 $\pm$ 111.38	4773.09 $\pm$ 220.32
NGC 4434	30.14 $\pm$ 8.20	-18.71 $\pm$ 19.08	-38.95 $\pm$ 325.27	117.37 $\pm$ 81.72	-65.32 $\pm$ 216.26
NGC 4435	80.42 $\pm$ 25.76	110.38 $\pm$ 37.37	1990.00 $\pm$ 43.00 ^a	2903.77 $\pm$ 113.81	4137.15 $\pm$ 238.08
NGC 4442	51.98 $\pm$ 14.46	10.77 $\pm$ 27.39	-615.07 $\pm$ 439.86	-91.50 $\pm$ 72.05	-572.90 $\pm$ 232.99
NGC 4452	21.14 $\pm$ 11.25	17.00 $\pm$ 16.46	-581.27 $\pm$ 390.31	...	-140.65 $\pm$ 122.96
NGC 4458	14.87 $\pm$ 10.52	-14.78 $\pm$ 18.09	0.00 $\pm$ 34.00 ^a	0.00 $\pm$ 142.00 ^a	100.27 $\pm$ 260.47
NGC 4459	113.03 $\pm$ 22.75	117.21 $\pm$ 28.83	1870.00 $\pm$ 66.00 ^a	4820.00 $\pm$ 134.00 ^a	4383.07 $\pm$ 348.11
NGC 4461	21.91 $\pm$ 12.97	-3.00 $\pm$ 24.00	0.00 $\pm$ 17.00 ^a	0.00 $\pm$ 85.00 ^a	-446.59 $\pm$ 388.00
NGC 4472	241.91 $\pm$ 41.93	179.83 $\pm$ 73.48	-55.87 $\pm$ 412.51	35.78 $\pm$ 135.63	90.24 $\pm$ 191.68
NGC 4473	91.54 $\pm$ 13.83	-2.54 $\pm$ 25.28	...	-299.87 $\pm$ 177.94	...
NGC 4474	23.85 $\pm$ 12.70	41.36 $\pm$ 21.55	...	-15.77 $\pm$ 64.22	-142.11 $\pm$ 159.17
NGC 4476	18.18 $\pm$ 8.20	30.69 $\pm$ 14.33	2078.80 $\pm$ 539.68	946.12 $\pm$ 108.40	884.13 $\pm$ 173.16
NGC 4477	37.97 $\pm$ 19.35	38.76 $\pm$ 32.30	570.00 $\pm$ 51.00 ^a	1410.00 $\pm$ 98.00 ^a	838.00 $\pm$ 311.98
NGC 4478	56.41 $\pm$ 10.11	25.25 $\pm$ 19.65	302.94 $\pm$ 546.84	-163.28 $\pm$ 150.33	93.09 $\pm$ 114.23
NGC 4483	12.21 $\pm$ 10.00	2.83 $\pm$ 19.27	-533.86 $\pm$ 302.18	322.09 $\pm$ 68.73	431.49 $\pm$ 135.87
NGC 4486	188.94 $\pm$ 34.92	152.94 $\pm$ 55.81	493.03 $\pm$ 402.78	363.37 $\pm$ 97.78	295.53 $\pm$ 184.34
NGC 4486A	29.46 $\pm$ 6.85	-0.33 $\pm$ 12.95	-139.45 $\pm$ 200.96	133.35 $\pm$ 57.10	-189.41 $\pm$ 108.78
NGC 4489	18.20 $\pm$ 13.29	8.89 $\pm$ 19.40	-408.35 $\pm$ 418.32	147.47 $\pm$ 88.68	-158.61 $\pm$ 210.81
NGC 4494	86.94 $\pm$ 22.23	32.36 $\pm$ 37.42	-149.45 $\pm$ 285.98	320.01 $\pm$ 66.84	28.49 $\pm$ 84.76
NGC 4503	41.26 $\pm$ 19.02	2.15 $\pm$ 29.03	-18.45 $\pm$ 558.24	-207.32 $\pm$ 199.74	...
NGC 4521	21.24 $\pm$ 6.93	24.03 $\pm$ 11.14	107.26 $\pm$ 210.10	422.05 $\pm$ 48.64	126.09 $\pm$ 65.61
NGC 4526	257.98 $\pm$ 22.98	236.26 $\pm$ 34.27	5831.36 $\pm$ 651.64	9830.22 $\pm$ 142.13	17367.27 $\pm$ 220.50
NGC 4528	0.09 $\pm$ 10.83	26.26 $\pm$ 15.10	-110.81 $\pm$ 411.30	287.82 $\pm$ 81.49	469.53 $\pm$ 186.81
NGC 4546	96.69 $\pm$ 12.58	-1.18 $\pm$ 38.78	279.24 $\pm$ 377.19	517.45 $\pm$ 82.54	17.78 $\pm$ 226.18
NGC 4550	24.06 $\pm$ 11.67	-8.78 $\pm$ 15.37	-81.48 $\pm$ 511.47	282.87 $\pm$ 96.03	-996.11 $\pm$ 401.41
NGC 4551	-14.20 $\pm$ 17.31	11.15 $\pm$ 18.29	329.39 $\pm$ 512.85	-74.65 $\pm$ 108.47	...
NGC 4552	107.71 $\pm$ 17.95	-0.02 $\pm$ 41.01	232.93 $\pm$ 336.62	367.38 $\pm$ 66.98	1109.74 $\pm$ 197.04
NGC 4564	60.57 $\pm$ 12.41	19.63 $\pm$ 16.98	0.00 $\pm$ 60.00 ^a	0.00 $\pm$ 190.00 ^a	-475.01 $\pm$ 170.92
NGC 4570	31.96 $\pm$ 12.45	21.90 $\pm$ 21.53	-184.23 $\pm$ 528.79	250.29 $\pm$ 157.37	126.29 $\pm$ 323.66
NGC 4578	21.93 $\pm$ 15.68	24.57 $\pm$ 27.69	...	59.41 $\pm$ 88.71	64.02 $\pm$ 172.67
NGC 4596	63.86 $\pm$ 21.78	74.77 $\pm$ 33.61	1339.50 $\pm$ 414.85	1277.59 $\pm$ 95.16	506.42 $\pm$ 204.10
NGC 4608	34.09 $\pm$ 15.10	43.23 $\pm$ 24.55	-235.42 $\pm$ 277.04	-144.02 $\pm$ 70.34	6.48 $\pm$ 145.94
NGC 4612	8.32 $\pm$ 15.14	8.76 $\pm$ 21.77	...	100.31 $\pm$ 80.09	-80.61 $\pm$ 59.69
NGC 4621	64.90 $\pm$ 27.12	50.73 $\pm$ 39.48	...	646.07 $\pm$ 97.82	926.39 $\pm$ 227.38

Table A.1. continued.

Galaxy	9 μm (mJy)	18 μm (mJy)	65 μm (mJy)	90 μm (mJy)	140 μm (mJy)
NGC 4623	5.40 $\pm$ 13.56	16.28 $\pm$ 16.23	... ^b	70.46 $\pm$ 69.80	-180.20 $\pm$ 101.99
NGC 4624	44.06 $\pm$ 24.17	35.60 $\pm$ 37.87	-106.55 $\pm$ 488.77	-100.16 $\pm$ 113.49	-300.26 $\pm$ 239.78
NGC 4636	141.18 $\pm$ 44.90	160.18 $\pm$ 72.60	-732.77 $\pm$ 692.54	669.91 $\pm$ 137.24	394.31 $\pm$ 567.50
NGC 4638	58.60 $\pm$ 8.79	17.46 $\pm$ 16.28	308.55 $\pm$ 446.42	46.39 $\pm$ 114.28	-15.83 $\pm$ 157.12
NGC 4643	86.87 $\pm$ 14.37	39.39 $\pm$ 28.22	... ^b	1843.36 $\pm$ 72.84	2156.65 $\pm$ 230.65
NGC 4649	186.90 $\pm$ 34.04	40.08 $\pm$ 53.25	... ^b	... ^b	... ^b
NGC 4660	19.31 $\pm$ 8.89	24.94 $\pm$ 13.17	0.00 $\pm$ 48.00 ^a	0.00 $\pm$ 101.00 ^a	-49.98 $\pm$ 250.14
NGC 4684	68.80 $\pm$ 14.16	142.39 $\pm$ 24.65	852.64 $\pm$ 416.86	1859.01 $\pm$ 89.08	1107.51 $\pm$ 286.47
NGC 4690	10.19 $\pm$ 9.54	10.04 $\pm$ 20.83	485.11 $\pm$ 257.94	136.39 $\pm$ 70.08	322.18 $\pm$ 206.45
NGC 4694	99.02 $\pm$ 18.29	15.58 $\pm$ 22.89	1820.17 $\pm$ 384.20	2533.78 $\pm$ 67.90	2177.04 $\pm$ 304.40
NGC 4697	88.96 $\pm$ 32.32	106.54 $\pm$ 50.51	460.00 $\pm$ 23.00 ^a	1240.00 $\pm$ 76.00 ^a	... ^a
NGC 4710	182.15 $\pm$ 15.42	231.89 $\pm$ 25.86	6201.75 $\pm$ 424.24	9966.46 $\pm$ 111.55	13399.18 $\pm$ 166.79
NGC 4733	2.18 $\pm$ 20.37	33.22 $\pm$ 30.51	... ^b	-0.67 $\pm$ 54.49	-40.62 $\pm$ 121.26
NGC 4753	203.52 $\pm$ 26.76	207.74 $\pm$ 55.62	2570.00 $\pm$ 59.00 ^a	9010.00 $\pm$ 199.00 ^a	... ^a
NGC 4754	95.93 $\pm$ 19.27	-2.14 $\pm$ 32.75	... ^b	-31.45 $\pm$ 62.43	... ^b
NGC 4762	78.81 $\pm$ 29.44	47.94 $\pm$ 43.99	... ^b	-39.04 $\pm$ 74.47	-67.60 $\pm$ 114.70
NGC 4803	5.36 $\pm$ 5.56	2.39 $\pm$ 11.07	478.41 $\pm$ 252.15	154.26 $\pm$ 51.59	300.41 $\pm$ 163.57
NGC 5103	3.47 $\pm$ 7.63	-13.38 $\pm$ 21.17	-247.56 $\pm$ 161.41	6.83 $\pm$ 41.27	48.20 $\pm$ 72.68
NGC 5173	52.33 $\pm$ 12.76	15.42 $\pm$ 10.61	354.56 $\pm$ 233.77	394.61 $\pm$ 50.30	275.97 $\pm$ 94.04
NGC 5198	33.05 $\pm$ 11.55	24.53 $\pm$ 17.27	161.88 $\pm$ 219.07	-56.73 $\pm$ 55.97	-136.02 $\pm$ 84.69
NGC 5273	73.00 $\pm$ 23.46	20.74 $\pm$ 33.49	378.69 $\pm$ 355.52	995.61 $\pm$ 72.55	285.04 $\pm$ 138.58
NGC 5308	47.24 $\pm$ 7.89	12.72 $\pm$ 10.76	-48.60 $\pm$ 135.83	150.77 $\pm$ 42.65	-21.90 $\pm$ 81.27
NGC 5322	46.06 $\pm$ 21.59	37.92 $\pm$ 34.19	1140.44 $\pm$ 232.14	692.98 $\pm$ 50.26	388.85 $\pm$ 84.81
NGC 5342	7.68 $\pm$ 4.86	0.02 $\pm$ 10.10	-50.72 $\pm$ 151.49	-80.12 $\pm$ 65.28	... ^b
NGC 5353	40.17 $\pm$ 11.97	33.71 $\pm$ 21.09	434.73 $\pm$ 349.67	898.18 $\pm$ 76.47	734.66 $\pm$ 106.89
NGC 5355	12.21 $\pm$ 6.62	-21.36 $\pm$ 22.15	... ^b	-6.63 $\pm$ 55.01	174.74 $\pm$ 116.72
NGC 5358	2.82 $\pm$ 7.67	-9.05 $\pm$ 13.51	... ^b	224.50 $\pm$ 59.60	-44.54 $\pm$ 85.97
NGC 5379	15.28 $\pm$ 9.59	1.62 $\pm$ 17.18	301.90 $\pm$ 407.09	208.95 $\pm$ 73.91	294.10 $\pm$ 127.16
NGC 5422	16.62 $\pm$ 8.12	28.72 $\pm$ 16.12	-288.41 $\pm$ 191.45	60.69 $\pm$ 44.72	390.89 $\pm$ 90.10
NGC 5473	7.35 $\pm$ 11.50	21.20 $\pm$ 14.44	... ^b	99.94 $\pm$ 46.76	250.44 $\pm$ 92.66
NGC 5475	16.62 $\pm$ 8.49	16.58 $\pm$ 12.57	-197.43 $\pm$ 120.18	83.20 $\pm$ 39.95	302.00 $\pm$ 80.72
NGC 5481	23.64 $\pm$ 11.53	7.11 $\pm$ 15.38	... ^b	... ^b	... ^b
NGC 5485	52.86 $\pm$ 13.13	-7.30 $\pm$ 25.52	20.03 $\pm$ 191.84	532.89 $\pm$ 45.33	314.45 $\pm$ 58.25
NGC 5493	22.71 $\pm$ 8.18	18.27 $\pm$ 13.11	... ^b	106.42 $\pm$ 91.99	-219.93 $\pm$ 204.90
NGC 5500	3.18 $\pm$ 8.75	-7.24 $\pm$ 14.02	... ^b	-7.92 $\pm$ 32.22	42.82 $\pm$ 72.80
NGC 5507	26.96 $\pm$ 8.02	-35.56 $\pm$ 19.09	... ^b	-61.91 $\pm$ 52.65	... ^b
NGC 5557	41.09 $\pm$ 17.19	36.40 $\pm$ 20.46	... ^b	-51.54 $\pm$ 36.16	-88.11 $\pm$ 32.44
NGC 5574	16.48 $\pm$ 10.05	23.60 $\pm$ 14.12	-54.16 $\pm$ 205.81	-131.17 $\pm$ 60.17	142.58 $\pm$ 154.36
NGC 5576	27.99 $\pm$ 14.05	8.18 $\pm$ 21.79	-277.59 $\pm$ 257.24	114.46 $\pm$ 55.48	284.84 $\pm$ 162.34
NGC 5582	22.45 $\pm$ 11.44	13.43 $\pm$ 15.49	-182.72 $\pm$ 210.41	63.70 $\pm$ 46.92	-12.90 $\pm$ 119.25
NGC 5611	-14.97 $\pm$ 6.31	-0.04 $\pm$ 9.48	125.85 $\pm$ 161.71	69.57 $\pm$ 40.86	75.65 $\pm$ 58.20
NGC 5631	34.83 $\pm$ 9.27	27.41 $\pm$ 14.23	664.72 $\pm$ 157.96	450.02 $\pm$ 44.79	583.97 $\pm$ 90.38
NGC 5638	19.56 $\pm$ 14.02	43.75 $\pm$ 23.75	-119.06 $\pm$ 243.23	123.18 $\pm$ 60.60	425.75 $\pm$ 112.82
NGC 5687	8.58 $\pm$ 11.42	6.48 $\pm$ 19.53	112.92 $\pm$ 188.29	-36.27 $\pm$ 63.11	-78.68 $\pm$ 84.16
NGC 5770	20.06 $\pm$ 9.83	-1.42 $\pm$ 16.23	-216.51 $\pm$ 220.83	8.83 $\pm$ 42.14	-167.82 $\pm$ 81.32
NGC 5813	26.36 $\pm$ 24.20	-38.93 $\pm$ 46.55	-341.86 $\pm$ 292.25	303.15 $\pm$ 105.28	527.34 $\pm$ 391.56
NGC 5831	10.24 $\pm$ 12.77	-0.70 $\pm$ 23.52	216.68 $\pm$ 284.05	130.87 $\pm$ 61.23	534.75 $\pm$ 180.20
NGC 5838	94.72 $\pm$ 14.23	74.35 $\pm$ 21.71	286.10 $\pm$ 396.65	1456.09 $\pm$ 57.23	1454.12 $\pm$ 150.54
NGC 5839	29.55 $\pm$ 9.96	-0.24 $\pm$ 15.49	70.09 $\pm$ 212.18	89.23 $\pm$ 52.56	110.80 $\pm$ 131.97
NGC 5845	31.72 $\pm$ 4.92	18.33 $\pm$ 9.29	-105.88 $\pm$ 193.96	-35.86 $\pm$ 58.01	162.42 $\pm$ 209.18
NGC 5846	61.83 $\pm$ 24.82	22.87 $\pm$ 41.81	... ^b	263.42 $\pm$ 101.10	279.20 $\pm$ 281.01
NGC 5854	28.23 $\pm$ 10.67	28.17 $\pm$ 17.92	-280.27 $\pm$ 321.48	150.61 $\pm$ 83.17	487.45 $\pm$ 166.18
NGC 5864	-1.53 $\pm$ 13.82	12.23 $\pm$ 19.73	-255.83 $\pm$ 284.09	-71.18 $\pm$ 89.99	19.17 $\pm$ 133.75
NGC 5866	247.44 $\pm$ 15.23	220.79 $\pm$ 18.70	4573.14 $\pm$ 231.09	9188.32 $\pm$ 63.58	16097.43 $\pm$ 97.72
NGC 5869	33.70 $\pm$ 9.36	-1.64 $\pm$ 20.76	... ^b	-26.85 $\pm$ 55.05	-530.31 $\pm$ 276.70
NGC 6010	16.40 $\pm$ 8.08	13.35 $\pm$ 12.59	-498.45 $\pm$ 310.18	-126.90 $\pm$ 72.46	121.03 $\pm$ 234.77
NGC 6014	32.86 $\pm$ 11.84	86.45 $\pm$ 21.39	1150.65 $\pm$ 214.66	1510.87 $\pm$ 55.20	1860.82 $\pm$ 131.97
NGC 6017	20.01 $\pm$ 5.73	24.47 $\pm$ 8.95	-1.68 $\pm$ 257.38	205.26 $\pm$ 74.45	923.82 $\pm$ 166.59

Table A.1. continued.

Galaxy	9 μm (mJy)	18 μm (mJy)	65 μm (mJy)	90 μm (mJy)	140 μm (mJy)
NGC 6149	14.93 $\pm$ 5.97	-9.64 $\pm$ 16.95	-19.44 $\pm$ 173.33	348.69 $\pm$ 49.72	117.30 $\pm$ 143.58
NGC 6278	26.75 $\pm$ 9.29	6.97 $\pm$ 15.92	... ^b	297.77 $\pm$ 53.72	377.40 $\pm$ 126.89
NGC 6547	13.14 $\pm$ 6.92	-18.76 $\pm$ 21.64	-241.07 $\pm$ 301.53	228.20 $\pm$ 76.26	-152.64 $\pm$ 261.41
NGC 6548	10.23 $\pm$ 13.42	32.97 $\pm$ 20.56	-61.13 $\pm$ 154.50	-46.67 $\pm$ 78.66	-162.35 $\pm$ 206.26
NGC 6703	49.16 $\pm$ 8.75	-6.75 $\pm$ 16.33	-31.14 $\pm$ 161.19	193.97 $\pm$ 52.73	-840.04 $\pm$ 469.52
NGC 6798	13.11 $\pm$ 6.40	4.92 $\pm$ 11.57	-187.04 $\pm$ 109.85	35.84 $\pm$ 57.60	50.47 $\pm$ 281.29
NGC 7280	23.13 $\pm$ 12.90	15.20 $\pm$ 17.56	82.76 $\pm$ 190.65	149.60 $\pm$ 64.97	144.04 $\pm$ 81.36
NGC 7332	21.68 $\pm$ 10.26	20.75 $\pm$ 14.83	257.81 $\pm$ 152.79	55.37 $\pm$ 82.16	310.47 $\pm$ 74.44
NGC 7454	0.82 $\pm$ 13.10	3.82 $\pm$ 23.14	... ^b	97.14 $\pm$ 57.51	66.64 $\pm$ 176.45
NGC 7457	54.97 $\pm$ 18.49	20.51 $\pm$ 32.74	-245.86 $\pm$ 236.09	32.91 $\pm$ 45.43	94.83 $\pm$ 121.33
NGC 7465	184.93 $\pm$ 6.03	243.18 $\pm$ 9.17	2076.94 $\pm$ 196.93	6169.73 $\pm$ 65.99	6094.62 $\pm$ 194.56
NGC 7693	-5.90 $\pm$ 7.65	-13.63 $\pm$ 22.58	... ^b	151.03 $\pm$ 63.74	387.38 $\pm$ 278.60
NGC 7710	5.85 $\pm$ 5.12	-11.45 $\pm$ 11.78	-74.10 $\pm$ 283.14	108.80 $\pm$ 68.36	580.37 $\pm$ 281.26
PGC 016060	19.29 $\pm$ 9.17	13.90 $\pm$ 9.93	-55.66 $\pm$ 308.03	1064.04 $\pm$ 69.06	982.56 $\pm$ 248.02
PGC 028887	8.56 $\pm$ 8.68	-8.96 $\pm$ 15.90	-332.74 $\pm$ 265.98	213.40 $\pm$ 56.91	264.66 $\pm$ 253.68
PGC 029321	63.74 $\pm$ 5.01	227.68 $\pm$ 10.09	1083.73 $\pm$ 307.99	1097.12 $\pm$ 65.28	1156.41 $\pm$ 238.88
PGC 035754	4.19 $\pm$ 3.95	-6.10 $\pm$ 10.61	... ^b	-20.85 $\pm$ 41.12	-33.91 $\pm$ 79.34
PGC 042549	-2.21 $\pm$ 7.01	-29.53 $\pm$ 24.42	... ^a	... ^a	... ^a
PGC 044433	2.41 $\pm$ 6.00	-1.38 $\pm$ 10.35	-236.57 $\pm$ 292.85	-37.56 $\pm$ 73.37	39.97 $\pm$ 190.85
PGC 050395	8.44 $\pm$ 5.40	-4.19 $\pm$ 11.49	... ^b	6.84 $\pm$ 45.90	97.04 $\pm$ 64.02
PGC 051753	2.14 $\pm$ 5.70	-9.57 $\pm$ 9.72	-208.24 $\pm$ 240.44	30.94 $\pm$ 61.57	49.97 $\pm$ 100.88
PGC 054452	12.23 $\pm$ 7.99	-0.34 $\pm$ 12.43	71.71 $\pm$ 216.15	255.98 $\pm$ 63.11	22.32 $\pm$ 59.05
PGC 056772	21.14 $\pm$ 7.11	71.15 $\pm$ 9.05	1489.64 $\pm$ 246.96	1246.73 $\pm$ 58.33	804.77 $\pm$ 190.37
PGC 058114	106.79 $\pm$ 8.09	305.10 $\pm$ 10.59	2455.07 $\pm$ 229.21	4007.11 $\pm$ 64.68	2999.71 $\pm$ 258.96
PGC 061468	23.62 $\pm$ 6.70	7.49 $\pm$ 14.56	249.49 $\pm$ 230.55	292.99 $\pm$ 56.56	607.21 $\pm$ 184.07
PGC 071531	1.01 $\pm$ 5.40	-0.38 $\pm$ 8.13	-331.86 $\pm$ 230.12	-87.59 $\pm$ 77.01	-100.15 $\pm$ 245.86
PGC 170172	-18.63 $\pm$ 9.12	-6.40 $\pm$ 14.42	-391.44 $\pm$ 392.59	-174.39 $\pm$ 100.36	-122.34 $\pm$ 249.03
UGC 03960	13.43 $\pm$ 9.07	-17.13 $\pm$ 15.85	150.69 $\pm$ 355.43	134.69 $\pm$ 73.76	585.08 $\pm$ 287.11
UGC 04551	18.19 $\pm$ 7.09	-20.98 $\pm$ 15.97	-216.83 $\pm$ 229.21	63.44 $\pm$ 53.40	302.48 $\pm$ 136.38
UGC 05408	... ^a	108.44 $\pm$ 11.86	957.89 $\pm$ 233.95	1244.20 $\pm$ 50.19	656.04 $\pm$ 89.95
UGC 06062	10.90 $\pm$ 6.59	11.28 $\pm$ 11.08	-282.66 $\pm$ 305.20	-1.47 $\pm$ 58.69	-419.98 $\pm$ 151.66
UGC 06176	68.53 $\pm$ 6.14	118.46 $\pm$ 10.68	1462.14 $\pm$ 368.35	1947.63 $\pm$ 76.50	1454.00 $\pm$ 169.94
UGC 08876	2.75 $\pm$ 4.84	3.65 $\pm$ 10.24	-141.39 $\pm$ 231.93	113.92 $\pm$ 58.65	328.51 $\pm$ 125.43
UGC 09519	27.78 $\pm$ 5.87	28.14 $\pm$ 7.75	438.62 $\pm$ 169.53	583.64 $\pm$ 29.93	124.76 $\pm$ 47.40

Table A.2. Infrared luminosities derived from SED fitting.

Galaxy	L_{PAH} (10^{41} erg s $^{-1}$)	L_{warm} (10^{41} erg s $^{-1}$)	L_{cold} (10^{41} erg s $^{-1}$)
IC 0560	2.88 $\pm$ 1.09	2.53 $\pm$ 0.96	9.77 $\pm$ 3.31
IC 0598	1.79 $\pm$ 1.09	1.82 $\pm$ 0.78	11.94 $\pm$ 3.22
IC 0676	44.56 $\pm$ 5.63	91.41 $\pm$ 10.81	77.84 $\pm$ 13.03
IC 0719	32.99 $\pm$ 4.25	14.69 $\pm$ 4.17	71.24 $\pm$ 12.51
IC 0782	0.11 $\pm$ 0.41	0.26 $\pm$ 0.50	13.65 $\pm$ 4.53
IC 1024	48.60 $\pm$ 5.25	32.64 $\pm$ 4.10	152.36 $\pm$ 22.71
IC 3631	1.07 $\pm$ 0.80	1.40 $\pm$ 0.85	0.00 $\pm$ 5.04
NGC 0448	2.81 $\pm$ 1.30	0.52 $\pm$ 0.59	0.34 $\pm$ 2.61
NGC 0474	0.00 $\pm$ 2.26	1.25 $\pm$ 0.78	1.58 $\pm$ 4.16
NGC 0502	0.00 $\pm$ 0.78	0.25 $\pm$ 0.27	0.33 $\pm$ 3.63
NGC 0509	0.86 $\pm$ 0.63	1.16 $\pm$ 0.53	0.00 $\pm$ 2.42
NGC 0516	0.74 $\pm$ 0.72	0.13 $\pm$ 0.44	11.01 $\pm$ 4.40
NGC 0524	3.33 $\pm$ 4.89	9.06 $\pm$ 3.41	47.74 $\pm$ 9.13
NGC 0525	0.00 $\pm$ 0.32	0.49 $\pm$ 0.30	0.00 $\pm$ 3.74
NGC 0661	1.38 $\pm$ 1.61	0.85 $\pm$ 0.64	9.69 $\pm$ 3.89
NGC 0680	0.00 $\pm$ 2.76	2.57 $\pm$ 1.02	12.75 $\pm$ 5.19
NGC 1023	0.00 $\pm$ 1.60	2.60 $\pm$ 0.95	0.07 $\pm$ 0.31
NGC 1222	192.07 $\pm$ 19.37	462.57 $\pm$ 48.06	640.00 $\pm$ 96.96

Table A.2. continued.

Galaxy	L_{PAH} (10^{41} erg s $^{-1}$)	L_{warm} (10^{41} erg s $^{-1}$)	L_{cold} (10^{41} erg s $^{-1}$)
NGC 1248	1.27 ± 1.18	0.99 ± 0.60	4.08 ± 2.94
NGC 1266	34.99 ± 5.64	181.48 ± 20.38	556.85 ± 81.44
NGC 1289	2.27 ± 2.02	1.42 ± 0.91	45.43 ± 9.67
NGC 1665	0.73 ± 1.88	0.31 ± 1.01	0.00 ± 5.51
NGC 2549	1.40 ± 0.64	0.82 ± 0.36	0.00 ± 0.43
NGC 2577	2.17 ± 2.17	10.39 ± 3.91	88.74 ± 48.77
NGC 2592	1.04 ± 1.12	0.67 ± 0.44	0.00 ± 2.27
NGC 2679	0.58 ± 1.07	1.87 ± 0.80	7.97 ± 2.71
NGC 2685	6.53 ± 1.50	18.54 ± 5.32	17.85 ± 8.35
NGC 2699	1.43 ± 1.01	0.39 ± 0.31	1.92 ± 1.73
NGC 2764	155.91 ± 17.86	82.82 ± 12.23	389.60 ± 55.73
NGC 2768	3.76 ± 5.73	3.80 ± 1.87	9.32 ± 2.67
NGC 2824	22.89 ± 5.22	17.47 ± 3.42	98.87 ± 17.90
NGC 2852	0.00 ± 0.49	0.30 ± 0.27	0.89 ± 1.83
NGC 2859	8.46 ± 3.18	1.71 ± 1.20	18.21 ± 3.62
NGC 2880	0.83 ± 1.05	0.35 ± 0.39	5.55 ± 1.67
NGC 2950	1.91 ± 0.95	1.00 ± 0.55	0.72 ± 0.35
NGC 2962	4.26 ± 3.80	11.42 ± 4.79	51.00 ± 12.27
NGC 3032	15.85 ± 3.19	12.66 ± 1.88	51.51 ± 8.61
NGC 3073	4.56 ± 1.85	1.83 ± 0.71	1.87 ± 2.28
NGC 3098	1.31 ± 0.97	0.69 ± 0.52	0.00 ± 1.58
NGC 3156	2.68 ± 1.13	1.75 ± 0.74	10.41 ± 2.52
NGC 3182	11.51 ± 3.83	6.10 ± 1.84	18.99 ± 4.21
NGC 3193	6.95 ± 4.70	1.77 ± 1.44	1.36 ± 2.96
NGC 3230	6.10 ± 4.09	1.93 ± 1.62	10.64 ± 4.46
NGC 3245	4.10 ± 2.71	13.16 ± 2.21	45.16 ± 7.16
NGC 3248	0.69 ± 0.74	0.00 ± 0.23	0.00 ± 1.49
NGC 3301	6.12 ± 1.99	19.89 ± 6.36	24.82 ± 8.33
NGC 3377	0.79 ± 0.72	0.85 ± 0.40	0.14 ± 0.35
NGC 3379	0.00 ± 1.18	1.27 ± 0.67	0.00 ± 0.20
NGC 3384	0.91 ± 1.17	1.06 ± 0.56	0.00 ± 0.31
NGC 3400	0.26 ± 0.43	0.43 ± 0.30	0.86 ± 1.24
NGC 3412	0.88 ± 0.71	0.25 ± 0.28	0.00 ± 0.37
NGC 3414	4.04 ± 3.11	20.00 ± 5.84	18.04 ± 9.00
NGC 3457	1.16 ± 0.57	0.33 ± 0.20	3.54 ± 1.25
NGC 3489	4.59 ± 1.10	3.80 ± 1.05	14.13 ± 2.31
NGC 3499	3.59 ± 1.14	0.82 ± 0.35	2.69 ± 1.05
NGC 3522	0.00 ± 0.23	0.00 ± 0.02	3.52 ± 1.70
NGC 3530	0.03 ± 0.42	0.38 ± 0.31	4.07 ± 1.70
NGC 3595	1.13 ± 1.50	0.29 ± 0.49	18.66 ± 5.20
NGC 3599	2.56 ± 1.13	2.31 ± 0.88	6.44 ± 1.79
NGC 3607	7.84 ± 6.23	7.17 ± 2.75	53.58 ± 8.47
NGC 3608	3.27 ± 2.14	1.29 ± 0.85	0.01 ± 2.23
NGC 3610	1.87 ± 1.74	2.17 ± 0.83	0.10 ± 1.25
NGC 3613	2.35 ± 3.16	0.86 ± 1.19	0.00 ± 2.29
NGC 3619	14.26 ± 4.30	4.39 ± 1.67	35.23 ± 6.26
NGC 3626	15.81 ± 2.97	16.34 ± 3.05	52.54 ± 8.79
NGC 3630	1.98 ± 1.18	0.68 ± 0.47	1.26 ± 2.46
NGC 3640	8.56 ± 4.57	5.05 ± 2.34	0.00 ± 1.60
NGC 3648	0.04 ± 1.31	0.99 ± 0.58	0.00 ± 2.05
NGC 3658	4.90 ± 2.47	2.69 ± 1.18	6.75 ± 2.64
NGC 3665	45.06 ± 9.88	24.41 ± 6.35	177.61 ± 27.85
NGC 3674	0.87 ± 1.35	0.00 ± 0.47	0.00 ± 1.91
NGC 3694	9.91 ± 3.25	5.69 ± 2.04	71.68 ± 11.96
NGC 3757	0.32 ± 0.49	0.08 ± 0.19	0.00 ± 0.81
NGC 3796	0.55 ± 0.46	1.30 ± 0.55	4.88 ± 1.32
NGC 3838	0.69 ± 0.72	0.29 ± 0.25	4.03 ± 1.23
NGC 3941	2.86 ± 1.09	1.35 ± 0.51	1.46 ± 0.40
NGC 3945	0.98 ± 3.45	18.40 ± 6.56	11.99 ± 3.72

Table A.2. continued.

Galaxy	L_{PAH} (10^{41} erg s $^{-1}$)	L_{warm} (10^{41} erg s $^{-1}$)	L_{cold} (10^{41} erg s $^{-1}$)
NGC 3998	7.85 ± 1.70	6.10 ± 0.96	4.25 ± 0.80
NGC 4026	3.21 ± 0.97	0.52 ± 0.47	0.12 ± 0.31
NGC 4036	4.87 ± 3.82	4.54 ± 1.73	33.86 ± 5.79
NGC 4078	1.55 ± 1.50	1.13 ± 0.70	10.43 ± 3.73
NGC 4111	6.16 ± 1.27	4.57 ± 0.91	12.08 ± 2.19
NGC 4119	4.48 ± 1.74	2.84 ± 1.03	6.40 ± 1.46
NGC 4143	3.31 ± 1.23	1.77 ± 0.68	1.43 ± 0.54
NGC 4150	3.27 ± 0.78	2.05 ± 0.47	13.65 ± 2.10
NGC 4168	1.35 ± 2.93	2.28 ± 1.33	7.39 ± 3.41
NGC 4179	3.05 ± 1.14	0.00 ± 0.37	0.00 ± 1.00
NGC 4191	5.54 ± 2.60	1.46 ± 0.87	4.62 ± 6.40
NGC 4203	4.05 ± 1.88	5.74 ± 1.97	11.37 ± 2.14
NGC 4215	3.64 ± 2.02	1.14 ± 0.86	0.00 ± 3.08
NGC 4233	3.21 ± 3.12	12.77 ± 5.08	28.74 ± 12.63
NGC 4249	0.16 ± 0.54	0.05 ± 0.42	0.00 ± 3.05
NGC 4251	2.88 ± 1.68	1.97 ± 0.92	0.46 ± 0.59
NGC 4255	1.53 ± 1.25	0.17 ± 0.49	1.55 ± 2.50
NGC 4259	0.00 ± 0.35	0.17 ± 0.10	9.49 ± 6.18
NGC 4261	16.39 ± 7.92	11.78 ± 4.44	8.63 ± 3.93
NGC 4262	0.43 ± 0.63	0.34 ± 0.32	0.56 ± 0.71
NGC 4264	0.62 ± 1.25	0.88 ± 0.58	12.00 ± 5.24
NGC 4267	0.00 ± 1.10	0.79 ± 0.47	0.24 ± 0.89
NGC 4268	0.00 ± 0.96	2.75 ± 1.82	23.01 ± 6.40
NGC 4270	2.10 ± 2.35	0.68 ± 0.96	0.00 ± 3.23
NGC 4278	1.33 ± 1.59	8.69 ± 3.03	9.89 ± 2.19
NGC 4281	12.35 ± 3.56	6.60 ± 2.32	13.80 ± 3.55
NGC 4283	0.14 ± 0.42	0.44 ± 0.20	1.01 ± 0.51
NGC 4324	6.65 ± 1.67	2.49 ± 0.82	15.54 ± 3.66
NGC 4339	0.42 ± 0.68	0.48 ± 0.39	1.41 ± 1.29
NGC 4340	0.78 ± 1.21	0.61 ± 0.48	1.96 ± 0.93
NGC 4342	0.00 ± 0.40	0.14 ± 0.11	0.00 ± 0.68
NGC 4346	0.00 ± 0.64	0.81 ± 0.32	0.00 ± 0.54
NGC 4350	3.64 ± 1.10	5.37 ± 1.99	6.65 ± 1.51
NGC 4365	2.65 ± 5.80	5.65 ± 2.57	0.00 ± 2.00
NGC 4371	1.17 ± 1.55	1.37 ± 0.69	0.00 ± 1.15
NGC 4374	0.00 ± 4.59	6.49 ± 2.15	13.86 ± 3.04
NGC 4377	0.00 ± 0.38	0.93 ± 0.69	11.17 ± 2.63
NGC 4379	0.16 ± 0.54	0.19 ± 0.19	2.65 ± 1.07
NGC 4382	0.28 ± 5.50	7.17 ± 2.95	0.00 ± 1.44
NGC 4406	0.00 ± 4.98	3.07 ± 1.86	0.00 ± 1.79
NGC 4417	1.38 ± 0.93	1.05 ± 0.47	3.58 ± 1.07
NGC 4425	0.38 ± 0.53	0.15 ± 0.22	0.00 ± 1.44
NGC 4429	8.96 ± 3.41	14.43 ± 4.10	40.25 ± 7.28
NGC 4434	1.11 ± 0.79	0.27 ± 0.30	1.90 ± 1.66
NGC 4435	4.85 ± 2.81	8.51 ± 2.49	42.64 ± 8.13
NGC 4458	0.16 ± 0.35	0.08 ± 0.18	0.06 ± 0.85
NGC 4459	7.08 ± 2.93	6.84 ± 1.74	49.73 ± 14.73
NGC 4461	0.10 ± 1.08	0.50 ± 0.38	0.00 ± 0.50
NGC 4472	0.00 ± 6.54	9.14 ± 3.79	0.01 ± 1.38
NGC 4474	0.69 ± 0.65	0.49 ± 0.26	0.00 ± 0.62
NGC 4476	1.96 ± 1.06	1.68 ± 0.49	17.02 ± 3.22
NGC 4477	0.00 ± 2.02	2.68 ± 1.06	13.30 ± 4.33
NGC 4478	1.71 ± 0.87	0.77 ± 0.42	0.00 ± 1.16
NGC 4483	0.22 ± 0.39	0.38 ± 0.41	4.17 ± 1.15
NGC 4486	0.00 ± 5.49	14.13 ± 4.31	3.48 ± 1.37
NGC 4489	0.14 ± 0.30	0.13 ± 0.13	0.92 ± 0.86
NGC 4494	2.08 ± 2.54	2.20 ± 1.03	1.71 ± 0.73
NGC 4503	0.80 ± 1.30	0.83 ± 0.50	0.00 ± 2.30
NGC 4521	5.78 ± 3.21	5.27 ± 1.89	17.11 ± 4.35

Table A.2. continued.

Galaxy	L_{PAH} (10^{41} erg s $^{-1}$)	L_{warm} (10^{41} erg s $^{-1}$)	L_{cold} (10^{41} erg s $^{-1}$)
NGC 4526	17.10 ± 4.43	13.40 ± 2.64	124.33 ± 18.35
NGC 4528	0.00 ± 0.46	0.36 ± 0.25	3.12 ± 0.99
NGC 4546	3.25 ± 1.22	1.79 ± 0.79	2.98 ± 0.89
NGC 4550	0.71 ± 0.65	0.38 ± 0.28	2.40 ± 1.10
NGC 4551	0.01 ± 0.53	0.27 ± 0.22	0.00 ± 1.19
NGC 4552	1.27 ± 2.26	5.23 ± 2.53	3.29 ± 1.14
NGC 4564	1.74 ± 1.06	0.67 ± 0.48	0.00 ± 1.19
NGC 4570	0.00 ± 1.38	1.63 ± 0.87	2.52 ± 1.80
NGC 4578	0.40 ± 0.81	0.98 ± 0.55	0.61 ± 0.89
NGC 4596	3.55 ± 2.34	3.96 ± 2.21	18.67 ± 3.62
NGC 4608	0.76 ± 1.01	0.45 ± 0.44	0.00 ± 0.77
NGC 4612	0.26 ± 0.77	0.67 ± 0.36	0.00 ± 0.63
NGC 4621	0.00 ± 2.40	1.51 ± 0.73	6.64 ± 1.53
NGC 4623	0.26 ± 0.41	0.88 ± 0.39	0.15 ± 0.80
NGC 4624	1.68 ± 2.41	1.64 ± 1.11	0.00 ± 1.22
NGC 4636	2.29 ± 3.28	3.67 ± 1.60	4.98 ± 1.56
NGC 4638	2.45 ± 1.02	0.46 ± 0.59	0.36 ± 1.19
NGC 4643	5.09 ± 2.04	14.83 ± 5.52	18.26 ± 4.32
NGC 4660	0.00 ± 0.70	0.95 ± 0.36	0.00 ± 0.70
NGC 4684	3.69 ± 1.05	11.26 ± 2.08	10.83 ± 2.24
NGC 4690	0.43 ± 1.06	0.96 ± 0.68	11.07 ± 4.87
NGC 4694	10.91 ± 2.22	16.53 ± 6.01	25.37 ± 5.26
NGC 4710	18.91 ± 3.10	26.39 ± 4.21	120.70 ± 17.64
NGC 4733	0.16 ± 0.38	0.27 ± 0.18	0.00 ± 0.44
NGC 4753	27.18 ± 8.51	19.43 ± 4.91	167.56 ± 60.22
NGC 4754	2.95 ± 1.77	1.34 ± 0.81	0.00 ± 0.69
NGC 4762	4.87 ± 4.46	2.18 ± 1.86	0.00 ± 1.37
NGC 4803	0.05 ± 0.52	0.00 ± 0.42	11.29 ± 3.77
NGC 5103	0.30 ± 0.67	0.33 ± 0.31	0.22 ± 0.83
NGC 5173	17.11 ± 4.42	4.73 ± 1.81	22.94 ± 5.00
NGC 5198	3.32 ± 3.11	2.00 ± 1.20	0.00 ± 3.31
NGC 5273	4.61 ± 1.58	4.24 ± 1.46	6.54 ± 1.55
NGC 5308	5.87 ± 2.80	1.58 ± 1.27	3.89 ± 1.82
NGC 5322	0.00 ± 7.58	45.42 ± 15.54	17.11 ± 7.98
NGC 5353	2.28 ± 6.65	24.23 ± 9.08	40.04 ± 9.01
NGC 5355	3.14 ± 1.40	1.23 ± 0.59	0.84 ± 2.98
NGC 5358	0.00 ± 0.36	0.19 ± 0.30	6.83 ± 3.46
NGC 5379	7.41 ± 2.62	6.87 ± 2.42	8.08 ± 2.94
NGC 5422	1.49 ± 2.07	1.68 ± 0.87	2.56 ± 1.80
NGC 5473	0.30 ± 3.81	3.35 ± 1.38	5.06 ± 2.24
NGC 5475	2.08 ± 1.37	1.35 ± 0.59	4.05 ± 1.75
NGC 5485	6.88 ± 2.71	3.36 ± 1.63	11.03 ± 2.44
NGC 5493	4.20 ± 4.41	3.66 ± 1.77	3.54 ± 5.54
NGC 5500	0.00 ± 0.36	0.34 ± 0.20	0.00 ± 1.25
NGC 5557	8.30 ± 6.82	3.89 ± 2.23	0.00 ± 1.96
NGC 5574	1.19 ± 0.82	0.87 ± 0.38	0.00 ± 1.37
NGC 5576	0.11 ± 2.73	1.83 ± 0.99	2.93 ± 1.49
NGC 5582	0.61 ± 1.31	0.51 ± 0.39	1.52 ± 1.45
NGC 5631	6.55 ± 2.75	26.90 ± 7.77	5.22 ± 4.59
NGC 5638	0.54 ± 2.14	1.80 ± 0.86	3.66 ± 1.73
NGC 5687	0.37 ± 1.34	0.98 ± 0.55	0.00 ± 1.62
NGC 5770	0.64 ± 0.59	0.29 ± 0.21	0.00 ± 0.57
NGC 5813	0.00 ± 6.44	4.40 ± 2.42	11.24 ± 4.77
NGC 5831	0.26 ± 2.04	1.57 ± 0.76	4.30 ± 1.90
NGC 5838	9.80 ± 3.18	5.55 ± 1.75	28.46 ± 5.48
NGC 5839	0.97 ± 0.78	0.42 ± 0.27	1.86 ± 1.05
NGC 5845	3.22 ± 1.11	0.88 ± 0.42	0.00 ± 1.63
NGC 5846	0.00 ± 5.83	4.16 ± 2.15	6.22 ± 2.64
NGC 5854	1.94 ± 1.59	1.82 ± 0.77	4.68 ± 2.43

Table A.2. continued.

Galaxy	L_{PAH} (10^{41} erg s $^{-1}$)	L_{warm} (10^{41} erg s $^{-1}$)	L_{cold} (10^{41} erg s $^{-1}$)
NGC 5864	0.35 ± 2.10	1.69 ± 0.85	0.00 ± 2.64
NGC 5866	16.42 ± 3.10	7.99 ± 1.28	89.87 ± 12.55
NGC 5869	1.35 ± 1.30	0.94 ± 0.52	0.00 ± 1.43
NGC 6010	1.71 ± 1.91	1.65 ± 0.94	0.00 ± 2.87
NGC 6014	21.27 ± 6.08	54.19 ± 11.78	82.08 ± 14.54
NGC 6017	5.90 ± 1.76	3.05 ± 0.98	7.56 ± 2.93
NGC 6149	2.40 ± 1.25	1.39 ± 0.77	16.22 ± 4.27
NGC 6278	4.58 ± 3.59	3.69 ± 1.64	23.46 ± 5.85
NGC 6547	2.50 ± 2.25	0.82 ± 0.87	12.49 ± 5.86
NGC 6548	1.33 ± 1.71	1.60 ± 0.74	0.00 ± 1.54
NGC 6703	4.57 ± 2.21	1.75 ± 1.01	4.75 ± 1.81
NGC 6798	6.42 ± 3.33	3.95 ± 1.58	0.49 ± 3.28
NGC 7280	3.01 ± 1.60	1.35 ± 0.66	3.41 ± 1.40
NGC 7332	0.00 ± 1.96	2.86 ± 1.08	2.38 ± 1.54
NGC 7457	0.95 ± 0.68	0.37 ± 0.26	0.22 ± 0.30
NGC 7465	73.39 ± 7.89	48.16 ± 5.84	195.90 ± 28.98
NGC 7693	0.16 ± 0.35	0.00 ± 0.32	8.48 ± 3.64
NGC 7710	0.54 ± 0.54	0.24 ± 0.37	5.78 ± 3.41
PGC 016060	13.20 ± 4.09	7.41 ± 2.60	54.90 ± 11.85
PGC 028887	0.00 ± 0.38	0.00 ± 0.49	14.38 ± 4.85
PGC 035754	0.04 ± 0.37	0.00 ± 0.30	0.00 ± 2.35
PGC 044433	0.01 ± 0.50	0.00 ± 0.52	0.00 ± 4.63
PGC 050395	0.00 ± 0.35	0.01 ± 0.04	1.69 ± 2.32
PGC 051753	0.08 ± 0.40	0.06 ± 0.31	1.90 ± 3.26
PGC 054452	0.12 ± 0.30	0.24 ± 0.23	3.83 ± 1.75
PGC 056772	11.26 ± 3.96	28.14 ± 4.33	94.24 ± 15.23
PGC 058114	27.13 ± 3.58	42.06 ± 4.58	96.42 ± 14.43
PGC 061468	6.47 ± 1.74	6.21 ± 2.28	17.11 ± 4.58
PGC 071531	0.02 ± 0.27	0.00 ± 0.03	0.00 ± 2.90
UGC 03960	0.00 ± 0.33	0.20 ± 0.33	7.05 ± 3.56
UGC 04551	0.24 ± 0.84	0.00 ± 0.36	2.42 ± 1.74
UGC 05408	23.70 ± 13.01	57.23 ± 8.30	110.84 ± 18.68
UGC 06062	1.92 ± 1.33	1.38 ± 0.70	0.00 ± 3.59
UGC 06176	49.25 ± 6.57	75.38 ± 10.55	132.13 ± 23.06
UGC 08876	0.20 ± 0.61	0.00 ± 0.33	6.08 ± 2.89
UGC 09519	8.69 ± 1.96	3.54 ± 0.94	13.75 ± 2.78

Appendix B

Fig. B.1. Continuation of Fig. 3.

Fig. B.1. continued.

Fig. B.1. continued.

Fig. B.1. continued.

Fig. B.1. continued.

Fig. B.1. continued.