The thesis presents results of a study of the optical and far-infrared properties of dust and ionized gas in a complete, blue magnitude-limited \((B_V<12)\) sample of 56 luminous elliptical (E) galaxies. To ensure consistency in the assignment of morphological types, the galaxy sample was drawn exclusively from the Revised Shapley–Ames Catalog of Bright Galaxies. A deep, systematic optical survey has been performed, including CCD imaging through both broadband filters and narrow-band filters. For each galaxy we have constructed color index \((B-V, B-I)\) images and images of the \(H\alpha+[N\,II]\)-emitting gas to derive the distributions of dust features and ionized gas. Long-slit spectra have also been obtained in two resolutions. Low-resolution spectra are used to study the properties of the underlying stellar populations (e.g., metallicity gradients), and to study the excitation mechanism of the ionized gas. Additional medium-resolution \((\sim 2\,\AA)\) spectra have been obtained for all sample elliptical galaxies containing ionized gas to study the kinematics of the gas, and derive pure \(H\alpha\) luminosities. In this thesis, analysis of the extensive imaging data and of the medium-resolution spectra is reported.

In Chapter 1 we report an early result of our survey: The galaxy IC 1459 is found to exhibit a large \((15\,\text{kpc}\) diameter) \(H\alpha+[N\,II]\) emission-line region, showing spiral structure. Patchy dust absorption is also found in the inner part of the emission-line region. This galaxy was already shown to contain a massive stellar core which counter-rotates rapidly with respect to the stellar body of the galaxy. Interestingly, the sense of rotation of the spiral "arms" of the ionized gas distribution is the same as that of the rapidly rotating stellar component in the center (assuming trailing spiral arms). These findings are clear signatures of an acquisition of a companion galaxy.

In Chapter 2 we present deep surface photometry of NGC 1275, the central dominant galaxy of the Perseus cluster. This peculiar galaxy features two distinct filamentary systems, \(3000\,\text{km}\,\text{s}^{-1}\) apart in velocity space. The "host"-galaxy NGC 1275 is associated with the low-velocity system, whereas the nature of the high-velocity system is still controversial. We find that prominent dust absorption features of NGC 1275 have the same distribution on the sky as the high-velocity system of ionized gas. Hence, the dust particles are most probably associated with the high-velocity system. However, our analysis of the excitation properties of the dust patches shows that the dust is well within NGC 1275, implying that the high-velocity system has moved approximately halfway through NGC 1275. We have also found many blue star clusters in our images of NGC 1275, for which we discuss the origin and nature by comparing color–magnitude diagrams with theoretical population models.

Chapter 3 presents the CCD broadband photometry of the sample ellipticals. Radial profiles of the surface brightness, colors, and characteristics of the detailed isophotal shape are derived. In addition, we show that fitting power laws to the outer radial intensity profiles of elliptical galaxies is an excellent tool for determining the sky background for CCD photometry.

Chapter 4 presents color-index images and narrow-band images of the \(H\alpha+[N\,II]\)-emitting gas to derive the distribution and amount of dust and ionized gas for the sample ellipticals. The detection rate of dust and ionized gas are found to be about 40% and 60%, respectively, which is significantly higher than that of previous imaging studies. The distributions of dust and ionized gas are consistent with being physically associated with each other.

The wavelength dependence of the dust extinction in elliptical galaxies with large-scale dust lanes are presented and discussed in chapter 5. We find that the dust grains in dust-lane elliptical galaxies are smaller on average than the canonical grain size in our galaxy. Comparing the typical lifetime of dust grains in different environments with formation time scales of lanes and/or rings in elliptical galaxies, we suggest that the observed characteristic dust grain size is determined by the time elapsed since the dust lane was accreted from outside.

In chapter 6 we combine the IRAS far-infrared observations, our optical survey data, and the available X-ray data of the galaxies in our sample. We find that dust masses as determined from the IRAS data are roughly an order of magnitude higher than those determined from optical extinction. To solve this dilemma we argue that the majority of the dust in elliptical galaxies exists as a diffusely distributed component. We show that this newly postulated distribution of dust is energetically consistent with the IRAS data. The diffuse component of dust is found to have a non-negligible effect on the radial color gradients in elliptical galaxies, and should thus be taken seriously in the interpretation of color gradients. Several arguments in favor of an external origin of dust in elliptical galaxies are discussed. Last but not least, a strong anticorrelation between the masses of dust and hot gas in X-ray luminous elliptical galaxies is found and discussed.