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Figure 7.12: Shear profiles measured in five clusters: Shown are, from top left to bottom right, CL 0159+0030 (centred on Rosat peak), CL 0230+1836, CL 0809+2811, CL 0809+2811 (centred on Rosat peak), CL 1357+6232, and CL 1416+4446. If not stated otherwise, the $S$-statistics centres are assumed. Within each plot, filled circles with error bars give the mean and standard deviation of the measured shear $\langle \varepsilon_t(\theta) \rangle$ in bins. Diamonds with error bars show the same for the cross component $\langle \varepsilon_\times(\theta) \rangle$. Dashed curves present the best NFW fits to the unbinned shear data of the respective cluster.
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Figure 7.13: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters minimising $\chi^2_L$ (Eq. 6.12) for three models of CL 0159+0030. Shown are the default model, including lensing catalogues sources at $\theta < 13'33''$ (solid contours and filled circle), the same model for $\theta < 15'0$ (dashed contours and arrow), and a model without correction for the shear dilution by cluster members (dot-dashed contours and square).

7.3.2 Mass Modelling for CL 0159+0030

The lensing analysis of CL 0159+0030 is determined and limited by the fact that this field has the largest masks near the cluster centre, due to a bright star at less than 2’ separation (Table 5.1). In our lensing catalogue defined in Sect. 7.2.1, we measure a smallest separation of $\theta = 112''$ for a background galaxy to the ROSAT centre of CL 0159+0030. This corresponds to a distance of 580 kpc at the cluster redshift of $z = 0.39$.

The masks resulting from the detection of over- and underdense regions (Sect. 5.1.3), using the default settings applied to all our cluster fields, can be seen in Fig. 7.23 in Sect. 7.4. The BCG of CL 0159+0030, just right to the ROSAT centre of CL 0159+0030 marked by a star symbol, resides in a region of the image strongly affected by stray light of the bright star. Orange contours in Fig. 7.23 give the $S$-statistics measured from the lensing catalogue, starting at $S = 0.5$ and with an increment of $\Delta S = 0.5$. Despite the large masks, the strongest $S$-peak in the field can be attributed to CL 0159+0030. Note that, due to the filter scale of $\theta_{out} = 10'5$ we applied in Fig. 7.23, we measure $S$ also in grid cells which are centred within masks. Indeed, the highest $S$-value is found in such a grid cell whose position and size of 15'' are indicated by a green square with error bars in Fig. 7.23.

Nevertheless, due to the masking, there is little variation between neighbouring grid cells in the masked area near the cluster. As a consequence, the position of the peak is less robust against variations in $m_{source}$ or $\theta_{out}$ than the $S$-peaks of the other clusters. Hence, we use the ROSSAT centre of CL 0159+0030 instead of the $S$-centre in subsequent analyses. We interpret the rather large
separation of $\Delta \theta = 79''$ between the two peaks as being mainly caused by the poor accuracy in the determination of the lensing centre.

The upper left panel of Fig. 7.12 shows the tangential shear profile $\langle \epsilon_t(\theta) \rangle$ of CL.0159+0030, using the ROSAT centre, in analogy to Fig. 6.12 for CL.0030+2618: We consider the weighted shear estimator $f_0 f_1(\theta) \epsilon(\theta)$, where $f_0 = 1.08$ is the global shear calibration factor and $f_1(\theta)$ the correction for cluster members determined in Sect. 7.3.1. This is done consistently for all three-band clusters. The measured $\langle \epsilon_t(\theta) \rangle$ (black symbols, shown in bins of 15' width) agrees well with an NFW profile (dashed curve), we fit using the same method as for CL.0030+2618 (Sect. 6.4.3), but keeping $c_{NFW} = 4.0$ fixed, as it is poorly constrained by our data set with few points near the cluster centre. Our fit assumes $(D_{ls}/D_s)=0.447$, estimated for $z_d=0.39$ in Table 6.4. We measure $\chi^2/\nu_{\text{dof}} = 6302/6229 \approx 1.01$ and obtain $r_{200}^\text{min} = 1.50 \pm 0.24$ Mpc. Noting a coincidence between the highest value of $\langle \epsilon_t(\theta) \rangle$ found in the $3'/0 \leq \theta < 4'/5$ bin with the value of the cross-component $\langle \epsilon_x(\theta) \rangle$ (open diamonds in Fig. 7.12) which is least consistent with zero, we emphasise that $\epsilon_x = 0$ lies within the 1σ margin for seven of nine bins.

To determine the mass of CL.0159+0030, we evaluate the merit function (Eq. 6.12) for a grid of points in $r_{200}$ and $c_{NFW}$, following the method of Sect. 6.4.4. The confidence contours resulting from the default model including all sources at $\theta < 13'33$ and otherwise assuming the same parameter values as for the fit to $\langle \epsilon_t(\theta) \rangle$ are presented in Fig. 7.13 (solid contours and filled circle). The minimum of $\chi^2_L$ (Eq. 6.12) is found for $r_{200}^\text{min} = 1.44^{+0.18}_{-0.22}$ Mpc. All quoted errors are statistical 1σ uncertainties for one interesting parameter. The corresponding concentration parameter $c_{NFW}^\text{min} = 9.2$ is hardly constrained by the data: In the default case, the upper 1σ limit of $c_{NFW}^\text{min} = 9.2$ is outside the range $0.05 \leq c_{NFW} < 16.00$ we probe. The same holds for the best value if all sources $\theta < 15'0$ are included in the analysis (dashed contours and diamond in Fig. 7.13). From the confidence contours, that for $c_{NFW} \gtrsim 3$ are basically parallel to the $c_{NFW}$-axis in Fig. 7.13, we conclude that our data cannot constrain it because of missing information at small $\theta$. We therefore give only a lower limit to $c_{NFW}$ in Table 7.3 (Sect. 7.3.9), where we compile the results for the default model of CL.0159+0030 and all variations to it that we tested. For example, “switching off” the correction for cluster members ($f_1(\theta) = 1$, dot-dashed contours and square in Fig. 7.13) has a small effect, insignificant compared to the statistical mass errors (Table 7.3). From $r_{200}^\text{min}$ for the default model, we compute $M_{200} = 5.4^{+2.3}_{-2.0} \times 10^{14} M_\odot$ for CL.0159+0030. We discuss this mass estimate and its uncertainties, estimated from the different models listed in Table 7.3, in Sect. 8.2. Confidence contours for these alternative models are presented in Fig. B.10 Appendix B.3.

### 7.3.3 Mass Modelling for CL.0809+2811

Concerning the large masks, CL.0809+2811 bears similarity to CL.0159+0030 and thus provides an interesting comparison. Here, the bright star is even closer to the ROSAT coordinates of the cluster (15', Table 5.1), but relative to the stronger shear signal (Table 7.2), the masking is not as extensive as for CL.0159+0030. This is visualised in Fig. 7.24, showing the $S$-contours and masks for CL.0809+2811 the same way Fig. 7.23 does for CL.0159+0030. The smallest separation of a source galaxy to the ROSAT coordinates of CL.0809+2811 we measure is $\theta = 83''$, or 430 kpc at the cluster redshift of $z=0.40$.

Being the second-strongest detection in our MEGACAM data set, the shear peak of CL.0809+2811 is by far the most prominent in its field. However, probably due to the loss of positional accuracy caused by the masking, the $S$-peak is separated by 178'' from the ROSAT centre. In contrast to CL.0159+0030, it makes a bigger difference for CL.0809+2811 whether the $S$-peak or the ROSAT centre is chosen as the centre of the shear profile.

The resulting tangential shear profiles are shown in the middle left (“L” as in lensing) and middle right (“R” as in ROSAT) plot of Fig. 7.12, respectively. Centred on the lensing peak, we
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Figure 7.14: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters minimising $\chi^2_L$ (Eq. 6.12) for four models of CL0809+2811. Shown are the default model, centred on the $S$-peak and including lensing catalogue sources at $1.5 < \theta < 15.0$ (solid contours and filled circle), the same model for $0' < \theta < 15.0$ (dashed contours and diamond), and a model without correction for shear dilution by cluster members (dot-dashed contours and square). The triple-dot dashed contours and diamond show the results of an analysis using the ROSAT centre of CL0809+2811.

measure a high $\langle \epsilon_i \rangle = 0.084 \pm 0.036$ in the innermost (1.5 < $\theta$ < 3.0) bin, compared to the $\langle \epsilon_i \rangle = 0.005 \pm 0.034$ if the centre is set to the ROSAT centre. Note that each of these bins contains only $\approx 1.4$% of the lensing catalogue. Concerning the NFW fit to the $\langle \epsilon_i(\theta) \rangle$ profile, the resulting values of $r_{f_{200}}^{\text{fit}} = 1.98 \pm 0.18$ Mpc for the “L” case and $r_{f_{200}}^{\text{fit}} = 1.81 \pm 0.20$ Mpc for the “R” case are in marginal agreement. Again, $c_{\text{NFW}} = 4.0$ was held fixed. We point out that the visual impression of binned shear profiles as in Fig. 7.12 can be misleading: The fits in the “L” case with $\chi^2/\nu_{\text{dof}} = 5818/5784 \approx 1.01$ and the “R” case with $\chi^2/\nu_{\text{dof}} = 5439/5408 \approx 1.01$ are statistically equally good. In both shear profiles, the factor $f_1(\theta)$ correcting for cluster members (Sect. 7.3.1) was obtained w.r.t. the correct centre, because we find a noticeable difference between the two cases. At $z_d = 0.40$, we assume $\langle D_{\Delta d}/D_s \rangle = 0.447$ for the NFW shear model. The cross-component $\langle \epsilon_X(\theta) \rangle$ is overall consistent with zero for the “L” profile and slightly biased to negative values for the “R” profile.

We base the default model for the evaluation of the $r_{200} - c_{\text{NFW}}$-grid on the $S$-peak of CL0809+2811 and compute Eq. (6.12) from all source galaxies at separations 1.5 < $\theta$ < 15.0. The resulting confidence contours are shown by the solid curves in Fig. 7.14. A filled circle represents cluster parameters minimising Eq. (6.12), $r_{f_{200}}^{\text{min}} = 1.83^{+0.16}_{-0.19}$ Mpc and $c_{\text{NFW}}^{\text{min}} = 3.7^{+2.2}_{-2.1}$. The concentration parameter is not well constrained by the data, but better as in CL0159+0030. Table 7.4 (Sect. 7.3.9) summarises the cluster parameters for all models we tested for CL0809+2811. Noting that the 1σ contour seems to close not too far outside the highest value $c_{\text{NFW}} = 16.0$ we tested, we plan
to explore higher concentrated models of CL 0809+2811 in the future. We constrain the mass of CL 0809+2811 to $M_{200} = 11.2^{+3.2}_{-3.2} \times 10^{14} M_\odot$.

Repeating the analysis of the $r_{200}$–cNFW–grid centred on the Rosat centre of CL 0809+2811, the results differ somewhat, although within the statistical uncertainty (triple-dot dashed contours and triangle in Fig. 7.14): We obtain a smaller $r_{\text{min}}^{200} = 1.71^{+0.23}_{-0.24}$ Mpc, but with larger uncertainties, leading to a mass estimate of $M_{200} = 9.2^{+4.7}_{-3.3} \times 10^{14} M_\odot$. The corresponding concentration parameter is at $c_{\text{min}}^{\text{NFW}} = 1.25^{+2.3}_{-0.9}$ better constrained to high values, but very small $c_{\text{NFW}} \approx 0$ are not ruled out. Changing the default, $\delta$-peak centred model of CL 0809+2811 by also including sources at separations $< 1.5$ (dashed contours and diamond in Fig. 7.14; note that the smallest separation is 64" in this case) or applying no correction for shear dilution by cluster members (dot-dashed contours and square in Fig. 7.14) result in smaller differences in the returned cluster parameters than using the Rosat centre. We refer to Table 7.4 for the values of $r_{\text{min}}^{200}$, $c_{\text{NFW}}$, and $M_{200}$ for those and other models we discuss in the error analysis in Sect. 8.2. Confidence contours for these alternative models are presented in Fig. B.12 in Appendix B.3.

### 7.3.4 Mass Modelling for CL 0230+1836

For our most distant and therefore most difficult cluster in terms of shear signal detection, CL 0230+1836 at $z_d = 0.80$, the masking poses a less severe problem than for CL 0159+0030 and CL 0809+2811. As shown in the overlay of the optical image (Fig. 7.25) with the masks (thin red lines) and the $S$-contours (thick orange lines, starting at $S = 0.5$ and increasing in steps of $\Delta S = 0.5$), the Rosat centre of CL 0230+1836 is located safely outside the masked region. In this case, the
separation between the bright star and the Rosat centre is larger (θ = 3′.59) than for the other two clusters. Besides the shear peak close to the Rosat centre and the likely BCG of CL 0230+1836, we observe several less significant shear peaks in the CL0230+1836 field.\footnote{We identify as the likely BCG of CL0230+1836 an elliptical galaxy at αJ2000 = 02h30m28.7 and δJ2000 = +18°36′11″, based on its extended light distribution. This galaxy is separated by 32′′ from the lensing centre.} We discuss these in Sect. 8.1.3. Searching for the shear peak using our usual grid of 15′′ mesh size, we find the Rosat centre (star symbol in Fig. 7.25) to be separated by 20′′ from the centre of the grid cell with the maximum S, and just outside this grid cell (green square with error bars in Fig. 7.25).

The upper right plot in Fig. 7.12 presents the tangential shear profile ⟨εt(θ)⟩ of CL 0230+1836. We measure a positive tangential alignment within ~7′ from the (lensing) cluster centre. There is no significant cross component ⟨εx(θ)⟩. Assuming (Dsrc/Dls) = 0.168 (Table 6.4), we fit an NFW shear profile to ⟨εt(θ)⟩ and find good agreement with χ2/νdef = 5488/5547 ≈ 0.99. The best-fit results for the cluster parameters are r200 = 1.51 ± 0.32 Mpc and cNFW = 3.4 ± 2.5. Note that because of the less extensive masking, we are able to constrain the concentration parameter better than for CL 0159+0030 and CL 0809+2811.

The high value for r200 returned by the Levenberg-Marquardt method with the σfit error model points to CL 0230+1836 being a very massive cluster, given its large redshift. We provide a more thorough mass estimation by applying the method introduced in Sect. 6.4.4. For our default model, we evaluate Eq. (6.12) for all source galaxies 0′ < θ < 13′:33 and measure its minimum for r200 = 1.40±0.24 Mpc and cNFW = 3.2±1.9. These results are illustrated by the filled circle and the solid confidence contours in Fig. 7.15. Via Eq. (6.7), our r200 corresponds to a mass of 8.1±4.0×1014 M⊙ for CL 0230+1836.

Excluding sources at separation θ < 0′.5 from the analysis does not alter the radius estimate significantly (r200 = 1.41±0.22 Mpc), but leads to a loss of constraining power for cNFW = 4.8±4.4 (see Table 7.5 in Sect. 7.3.9 and the dashed contours and square in Fig. 7.15), or without correction for cluster members (triple-dot-dashed contours and square in Fig. 7.15). The cluster parameters for further models, e.g. centred on the BCG position instead of the shear peak (dotted-dashed contours and square in Fig. 7.15), or without correction for cluster members (triple-dot-dashed contours and triangle in Fig. 7.15) are summarised in Table 7.5. We return to these results for the error analysis in Sect. 8.2. Here, we point out that repeating the analysis of the r200−cNFW−grid with the lensing catalogue derived from the magnitude cut at mlens = 23.4 that, as we saw in Sect. 7.2.1, results in a more significant detection of CL 0230+1836 than the default lensing catalogue, we obtain r200 = 1.51±0.24 Mpc and cNFW = 3.2±1.65, resulting in a higher mass estimate of 10.2±5.7×1014 M⊙ for CL 0230+1836, but within the statistical uncertainty. The confidence contours for these models are shown in Fig. B.11 in Appendix B.3.

### 7.3.5 Mass Modelling for CL 1357+6232

Figure 7.26 shows an overlay of the r′-band image of CL 1357+6232 with the S-statistics contours measured using the lensing catalogue we defined in Sect. 7.2.2. Despite being one of the two fields with the shallowest exposure (Texp = 2700 s) and having the poorest seeing of 0′.90 in our sample, we clearly detect CL 1357+6232 at a significance level of ≈ 4.5σ (Table 7.2) as the most significant shear peak in the field. Performing 10⁵ bootstrap resamples of the CL1357+6232 lensing catalogue using the same method as for CL0030+2618 (Sect. 6.3.1), we determine the lensing centre of CL 1357+6232 and its uncertainty (shown as a green filled circle with error bars in Fig. 7.26). We find the centre obtained by bootstrapping to lie inside the 15′′ wide grid cell giving the highest S value, which we used as a preliminary lensing centre. The separation of the final lensing centre from the Rosat centre is θ = 50′′; the one from the BCG candidate θ = 44′′. We measure θ = 19′′ separation between the Rosat centre and the BCG candidate (which is hardly visible in Fig. 7.26 because of the contour lines).
Figure 7.16: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters minimising $\chi^2_L$ (Eq. 6.12) for four models of CL 1357+6232. Solid contours and the filled circle denote the default model, including all sources within $0' < \theta < 15'$ around the lensing centre. Dashed contours and a diamond mark the model with a range $0'5 < \theta < 15'$. Models centred on the ROSAT centre and the BCG are given by dot-dashed contours and a square, and triple-dot dashed contours and a triangle, respectively.

As presented in the lower left plot of Fig. 7.12, CL 1357+6232 exhibits a positive tangential alignment $\langle \varepsilon_t(\theta) \rangle$ of source galaxies until $\sim 7'$ separation, and insignificant cross component $\langle \varepsilon_\times(\theta) \rangle$. Note that, for CL 1357+6232 and the other single-band clusters (Sect. 7.2.2) no correction for contamination by cluster members is applied to the shear estimates. Fitting an NFW profile to the $\varepsilon_t(\theta)$ with the Levenberg-Marquardt method gives a goodness-of-fit of $\chi^2/\nu_{\text{ dof}} = 7670/7761 \approx 0.99$ and a virial radius estimate $r^\text{fit}_{200} = 1.26 \pm 0.22$ Mpc and concentration parameter $c^\text{fit}_{\text{NFW}} = 2.9 \pm 2.1$ for CL 1357+6232, making it less massive than CL 0030+2618 at a similar redshift ($z_d = 0.53$ compared to $z_d = 0.50$ for the latter). We assume $\langle D_{\text{ds}}/D_s \rangle = 0.324$ (Table 6.4).

Computing the merit function (Eq. 6.12) for the same grid in $r_{200}$ and $c_{\text{NFW}}$ that we used for the three-band clusters, we obtain the following parameters minimising $\chi^2_L$ for CL 1357+6232: $r^\text{min}_{200} = 1.18^{+0.17}_{-0.20}$ Mpc and a concentration of $c^\text{min}_{\text{NFW}} = 2.8^{+1.65}_{-1.25}$. Thus, we infer a mass of $3.5^{+1.7}_{-1.5} \times 10^{14} M_\odot$. In this default model (filled circle and solid confidence contours in Fig. 7.16), all sources at $0' < \theta < 15'$ have been included. Table 7.6 in Sect. 7.3.9 lists the cluster parameters and masses for all models tested for CL 1357+6232. Removing sources $\theta < 0'5$ close to the cluster centre from the analysis (dashed contours and diamond in Fig. 7.16) leaves $r^\text{min}_{200}$ unchanged – indicating that the uncorrected dilution by cluster members is small – but leads to a larger uncertainty in $c_{\text{NFW}}$.  

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Figure 7.17: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters minimising $\chi^2_L$ (Eq. 6.12) for four models of CL 1416+4446. The default model (solid contours and filled circle) includes all sources in a range $0.5 < \theta < 12'$ around the lensing centre. A model with range $0.5 < \theta < 12'$ is given by dashed contours and a diamond. The dot-dashed contours and square, and the triple-dot dashed contours and triangle mark cases with the same two ranges, but centred on the Rosat centre.

such that the 1σ contours close beyond the largest value of $c_{NFW} = 16$ we tested.\(^4\) Models centred on the Rosat centre (dot-dashed contours and square in Fig. 7.16) or the BCG candidate (triple-dot dashed contours and triangle in Fig. 7.16) give slightly lower values for $r_{200}^\text{min}$ and, hence, the cluster mass (Table 7.6). Confidence contours for the further cases considered for the error analysis in Sect. 8.2 can be found in Fig. B.13 in Appendix B.3.

### 7.3.6 Mass Modelling for CL 1416+4446

At most filter scales $\theta_{\text{out}}$ in the $S$-statistics (Eq. 3.29), CL 1416+4446 is the weakest detection among the 400d clusters we analysed. Only at small filter scales $\theta_{\text{out}} \approx 5'$, it is detected at a $>4\sigma$ significance level. This gives a first hint of its low mass. Figure 7.27 shows the $S$-contours of CL 1416+4446 at the best filter scale, $\theta_{\text{out}} = 4.83$, overlaid on the $r'$-band MegaCam image. The overall pattern of the shear signal in Fig. 7.27 is robust also at larger $\theta_{\text{out}}$, meaning more smoothing: From the highest $S$-peak close to the Rosat centre of CL 1416+4446 (big star symbol in Fig. 7.27, also covering the BCG at $6''$ separation), the signal extends to a south-eastern direction. There exist two other shear peaks at $>3\sigma$ significance to the west and southwest of CL 1416+4446. As we will detail in Sec. 8.1.3, these peaks correspond to known clusters (small star symbols).

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\(^4\)We will extend the exploration of the parameter space to stronger concentrated models in the future.
at redshifts similar to \( z_d = 0.40 \) measured for CL 1416+4446. For the time being, we investigate CL 1416+4446 as a single cluster of galaxies.

Due to the morphology of the shear signal, the 1\( \sigma \) uncertainty in the shear centre derived from 10\(^5\) bootstrap resamples of the lensing catalogue (filled green circle with error bars in Fig. 7.27) is rather large: 43″ in the \( x^- \) or \( \alpha_{2000}^- \) direction and 56″ in the \( y^- \) or \( \delta_{2000}^- \) direction. We note that the bootstrapping lensing centre is south of the most significant grid cell (indicated in Fig. 7.27 by the 4\( \sigma \) contour) and the Rosat centre, which both are covered by its error ellipse.

The tangential shear profile of CL 1416+4446 in the lower right plot of Fig 7.12 shows a positive tangential component \( \langle \epsilon_t(\theta) \rangle \) in the inner \( \sim 5' \) around the shear centre. The cross component is consistent with zero. As for CL 1357+6232 no correction for cluster members could be applied to this single-band cluster. The \( \langle \epsilon_t(\theta) \rangle \) profile is well represented by an NFW fit (fitting the range \( 0'5 < \theta < 14'0 \) and assuming \( (D_{ds}/D_x) = 0.437 \) from Table 6.4), with \( \chi^2 / \nu_{\text{dof}} = 12639/12453 \approx 1.01 \). We obtain the parameters \( r_{200}^{\text{fit}} = 1.06 \pm 0.18 \text{ Mpc} \) and \( c_{\text{NFW}}^{\text{fit}} = 4.9 \pm 4.7 \) for CL 1416+4446.

Evaluating \( \chi^2_L \) on the \( r_{200}^{\text{NFW}}\)-grid, the default model with the above-mentioned range yields a radius estimate \( r_{200}^{\text{min}} = 0.99^{+0.14}_{-0.16} \text{ Mpc} \) (filled circle and solid confidence contours in Fig. 7.17). This results in a mass estimate of \( 1.8^{+0.3}_{-0.7} 	imes 10^{14} \text{ M}_\odot \) for CL 1416+4446. The 1\( \sigma \) confidence contours of the concentration parameter \( c_{\text{NFW}}^{\text{min}} = 4.9^{+5.6}_{-2.9} \) in the default model extend beyond \( c_{\text{NFW}} = 16 \), the largest tested value, as Table 7.7 in Sect. 7.3.9 shows.\(^5\) Including all sources \( 0' < \theta < 14' \) to the analysis, \( c_{\text{NFW}} \) is constrained better, with a slightly lower \( r_{200}^{\text{min}} \) (see Table 7.7 and diamond and dashed confidence contours in Fig. 7.17). Using the Rosat centre in the analysis of \( \chi^2_L \) returns higher values for \( c_{\text{NFW}} \), both in the case \( \theta_{\text{min}} = 0'5 \) (square and dotted contours in Fig. 7.17) and for \( \theta_{\text{min}} = 0' \) (triangle and triple-dot dashed contours in Fig. 7.17). This does not come unexpected, because the Rosat centre lies closer to the highest \( S \) grid cell than the bootstrapping lensing centre.

Table 7.7 includes the results for all models tested for CL 1416+4446. The confidence contours for the cases discussed in the error analysis (Sect. 8.2) are presented in Fig. B.14 in Appendix B.3.

### 7.3.7 Mass Modelling for CL 1701+6414

A weak lensing analysis of CL 1701+6414 has to deal with shear by multiple structures. At first glance, the Megacam image (shown in Fig. 7.28 overlaid with \( S \)-contours and masks) not only shows CL 1701+6414 – the five-pointed star symbol marks the Rosat centre – but also a rich cluster of galaxies \( \sim 4'5 \) to the west. Abell 2246 (big four-pointed star symbol in Fig. 7.28, masked due to the high concentration of galaxies) was detected as BVH 210 in the 400d survey (Burenin et al. 2007) with a luminosity \( L_X = 6.10 \times 10^{13} \text{ erg s}^{-1} \) in the Rosat 0.5–2.0 keV band and a redshift of \( z = 0.225 \). Thus, it is not part of the distant cosmological subsample (Sect. 4.1.2), but a likely cluster lens. Both CL 1701+6414 and A 2246 are also included in the 160d survey (Vikhlinin et al. 1998), as VMF 190 and VMF 189. This Rosat catalogue lists two further clusters in the field, VMF 191 at \( z = 0.220 \) and VMF 192 at \( z = 0.224 \) (small star symbols in Fig. 7.28).

Also from an analysis of Rosat data, Donahue et al. (2002) detect these same four clusters and a further one (RXJ1702+6407) which we do not detect. Applying the Postman et al. (1996) matched filter technique to KPNO 4m data, they assign optical counterparts to the four clusters included in the 160d survey. The redshift of \( z = 0.7 \) found for the Donahue et al. (2002) optical counterpart of CL 1701+6414 deviates from the redshift of \( z = 0.45 \) measured by Burenin et al. (2007) and all other references. CL 1701+6414 is further listed as RXJ1701.3+6414 in the Bright Serendipitous High-Redshift Archival Rosat Cluster sample (Bright SHARC, Romer et al. 2000).

As the \( S \)-contours in Fig. 7.28 show, all four known clusters correspond to regions of high \( M_{ap} \) significance. The strongest shear peak \( S = 4.3\sigma \) is located at the position of A 2246, whereas

\(^5\)Note that all errors given, e.g. in Table 7.7 are calculated for one interesting parameter.
Figure 7.18: Modelling the shear distribution around CL 1701+6414 and A 2246. *Upper plot:* Shown are the binned tangential ($\langle g_\| (\theta) \rangle$, filled circles with error bars) and cross components ($\langle g_\times (\theta) \rangle$, diamonds with error bars) of the shear w.r.t. the CL 1701+6414 lensing centre. The blue dashed line shows $\langle g_\|^{fit} (\theta) \rangle$ for the best-fit two-cluster model, while the orange long-dashed lines gives $\langle g_\times^{fit} (\theta) \rangle$ as expected for this model. Both model profiles are computed by averaging over the same annuli around the cluster centre as done for the data. Blue and orange shaded regions show the 1σ dispersions of the model values in these annuli. *Lower plot:* The orientations and amplitudes of the shear as expected from the best-fit two-cluster model, on a regular grid.
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Figure 7.19: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters from the simultaneous modelling of CL 1701+6414 and A 2246. Each panel shows the dependencies between two of the four parameters, with the other two marginalised. Solid contours denote the default case, centred on the shear peaks; dashed contours denote a model using ROSAT centres. The parameters minimising $\chi^2_{\text{L4}}$ for the two models are indicated by a filled circle and a triangle.

CL 1701+6414 is detected at the $3.7\sigma$ level. We stress that the lensing catalogue was optimised for the detection of CL 1701+6414 (Sect. 7.2.2). The smaller shear peaks at the coordinates of VMF 191 and VMF 192 measure $2.9\sigma$ and $2.7\sigma$, respectively, with another $3.1\sigma$ S-peak close-by. The shear signal we measure forms an extended band of >20' extent, reaching from the north-east of VMF 192 to a $3.6\sigma$ shear peak south-west of A 2246, which does not correspond to a known cluster.\(^6\) Noticing the very similar redshifts of A 2246, VMF 191, and VMF 192, we might observe a physical filament at $z=0.22$, through whose centre we observe CL 1701+6414 in projection. We plan to perform a mass reconstruction of our lensing catalogue in the future, to provide further insight into the mass distribution.

Luckily, there exists direct proof that CL 1701+6414 does act as a gravitational lens, and thus contributes to the lensing signal: We observe a likely strong lensing arc, 10'' to the west of

---

\(^6\)Inspection of the ROSAT image does not show any obvious, strong extended emission at this position.
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Figure 7.20: The same as Fig. 7.19, but for \( c_{s,NFW} = 20 \) held fixed such that two out of three parameters are shown, and we marginalise over the third parameter. In addition, we used a finer grid than for Fig. 7.19.

the BCG of CL 1701+6414 (\( z = 0.44 \pm 0.01 \), Reimers et al. 1997). We show a zoomed version of Fig. 7.28, detailing the centre of CL 1701+6414 in Fig. 7.29. This arc candidate was found already by Reimers et al. (1997), who detected CL 1701+6414 and A 2246 using Rosat PSPC data and optical imaging and spectroscopy with the Calar Alto 3.5 m and 2.2 m telescopes. Reimers et al. (1997) suggest that the very luminous QSO HS 1700+6414 at \( z' = 2.72 \) might be magnified by the combined lensing effects of the two clusters.

As the lensing centre, we define the grid cell with the highest \( S \)-value in the shear peak we attribute to CL 1701+6414, located 66" off the Rosat centre. Plotting the binned tangential shear around this lensing centre (filled circles in the upper plot of Fig. 7.18), we find a flat profile whose average \( \langle \epsilon_t(\theta) \rangle > 0 \) is consistent with the extended shear signal in the \( S \)-map. The cross-component \( \langle \epsilon_x(\theta) \rangle \) is consistent with zero. Attempts to fit \( \langle \epsilon_t(\theta) \rangle \) with our usual NFW profile (Eq. 6.8) produce nonsensical results because there is no preferred radial scale in a flat profile. Therefore, we modify our approach and, in a cautious step towards more complexity, model the shear of CL 1701+6414 and A 2246, the strongest shear peak, simultaneously.
In the two-cluster model, we assume an NFW shear profile originating from each deflector. We assume both the shear \( g_p \) of the primary and \( g_s \) of the secondary component to be small. In this case the superposition (Eq. 3.21) of the two polars becomes a simple addition. Thus, we expect the following shear components at a position \( \theta \) in the image plane:

\[
g_{\text{add},\alpha}(\theta) = g_{p,\alpha}(\theta; r_{p,200}, c_{p,NFW}) + g_{s,\alpha}(\theta; r_{s,200}, c_{s,NFW}) \quad , \quad \alpha = 1, 2 \quad .
\]  

(7.1)

Here, \( r_{p,200}, r_{s,200}, c_{p,NFW}, \) and \( c_{s,NFW} \) are the radii and concentration parameters of the primary and secondary component, resp. Note that \( g_{\text{add},\alpha}(\theta) \) explicitly depends on the two-dimensional coordinate vector \( \theta \); the shear field of two clusters no longer has radial, but only axial symmetry. This is illustrated in the lower panel of Fig. 7.18, showing the best-fit two-cluster model for the CL 1701+6414 lensing catalogue evaluated on a regular grid.

For this best-fit model with the Levenberg-Marquardt method, we assume the lensing peaks of CL 1701+6414 at \( z = 0.45 \) and A 2246 at \( z = 0.225 \) as the centres of the two clusters; further \( (D_{\text{ds}}/D_*) = 0.381 \) for CL 1701+6414 (Table 6.4) and \( (D_{\text{ds}}/D_*) = 0.640 \) for A 2246, calculated analogously. With a goodness-of-fit of \( \chi^2/\nu_{\text{ dof}} = 26469/26502 \approx 1.00 \), we obtain \( r_{p,200}^{\text{fit}} = 1.26 \pm 0.27 \) Mpc and \( c_{p,NFW}^{\text{fit}} = 0.3 \pm 0.5 \) for CL 1701+6414 and \( r_{s,200}^{\text{fit}} = 0.85 \pm 0.16 \) Mpc. The concentration \( c_{s,NFW} \) of A 2246 is unconstrained by the result of the Levenberg-Marquardt fit. Based on this model, we compute the tangential and cross-component of the shear expected at each source galaxy and present the resulting profile in the upper plot of Fig. 7.18. The equivalent to the radial bin in the radially symmetric shear profile are concentric annuli within which the model shear \( g_\alpha \) varies also azimuthally. For each annulus, we show the average and \( 1\sigma \) dispersion of \( g_\alpha \) as the blue dashed line and blue-shaded region. The orange long-dashed line and orange shaded region display the same quantities for \( g_s \). Note that the fitted shear components \( (g_{L,x}) \) are directly comparable to the measured \( (\langle \epsilon_{L,x} \rangle) \). Figure 7.18 shows the good agreement between the measured and fitted tangential shear. A vertical dotted line denotes the separation of CL 1701+6414 and A 2246. For similar separations, the dispersion in the fitted shear components is largest, because we average over points with vastly different separations to the two clusters. Finally, we note that although the cross-component can be large at some points in the image plane, \( (\epsilon_s) \) cancels out nearly completely when averaging over the annuli.

While the values for \( r_{200} \) returned in the fit seem reasonable, the concentration parameters for both clusters are ill-constrained, formally consistent with unphysical negative values. This problem is avoided using the method based on the parameter grid, which allows for asymmetric error margins. We consider a modification of the merit function given by Eq. (6.12):

\[
\chi^2_{L4} = \sum_{i=1}^{N_{\text{fit}}} \frac{\left| g_{\text{add},i}(r_{p,200}, c_{p,NFW}, r_{s,200}, c_{s,NFW}) - \epsilon_i \right|^2}{\sigma_{\text{fit}}^2 \left( 1 - \left| g_{\text{add},i}(r_{p,200}, c_{p,NFW}, r_{s,200}, c_{s,NFW}) \right| \right)^2} \quad .
\]  

(7.2)

The symbol \( \chi^2_{L4} \) highlights the dependence on four parameters, the radii and concentrations of the two clusters. We denote by \( (r_{p,200}^{\text{min}}, c_{p,NFW}^{\text{min}}, r_{s,200}^{\text{min}}, c_{s,NFW}^{\text{min}}) \) the cluster parameters minimising \( \chi^2_{L4} \). Note that \( \chi^2_{L4} \) models the measured \( \epsilon_i \) directly, without recursion to the tangential component.

Figure 7.19 presents the confidence contours and parameters minimising Eq. (7.2) for the default model which is centred on the lensing peaks and uses no separation limit (filled circle and solid contours). The panels of Fig. 7.19 show all combinations of two parameters, where we marginalised over the two remaining parameters. Owing to the 4-dimensional parameter space, we tested a coarse grid of points to avoid excessive computing time. The picture emerges that

\[\text{Note that} \quad g_s \quad \text{add,}\alpha(\theta) \quad \text{explicitly depends on the two-dimensional coordinate vector} \quad \theta; \quad \text{the shear field of two clusters no longer has radial, but only axial symmetry.} \]
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7.3.1 LENSING ANALYSIS

$r_{p,200}$ and $r_{s,200}$ are relatively independent of each other (top right panel). Hence, the presence of the respective other cluster does not seem to affect the accuracy with which we can determine the masses of the two clusters strongly. Consistent with the Levenberg-Marquardt fit results, the data favour the smallest tested value, $c_{p,NFW} = 0.5$ for the concentration of CL 1701+6414, and the largest tested value, $c_{s,NFW} = 15.5$ for the one of A 2246. Using ROSAT cluster centres (dashed contours and triangle in Figure 7.19), high $c_{p,NFW}$ are ruled out even more.

We notice that $c_{s,NFW}$ seems not to be well constrained by the data, which might explain the very high $c_{s,NFW}$ we obtained. A possible explanation is the masking of the immediate surroundings of A 2246 (see Fig. 7.28), barring the region in which $c_{s,NFW}$ can be constrained best from the analysis. Shear contribution of the BCG of A 2246 could mimic a strongly concentrated cluster. In an extended analysis, we plan to test if including a galaxy lens on top of the A 2246 profile improves the modelling.

Given the mask around A 2246 and the fact that the value of $c_{s,NFW}$ has little influence on $r_{p,200}$, the parameter important for determining the mass of CL 1701+6414, we fix $c_{s,NFW} = 20$ to a high, but reasonable value and repeat the analysis with a finer parameter grid for a 3-dimensional parameter space and $\chi^2_{L3}(r_{p,200}, c_{p,NFW}, r_{s,200})$. Now marginalising over only one parameter, the confidence contours in Fig. 7.20 confirm the results of Fig. 7.19. The best model is found for $r_{p,200}^{min} = 1.15^{+0.18}_{-0.20}$ Mpc, $c_{p,NFW}^{min} = 0.6^{+1.6}_{-0.6}$ and $r_{s,200}^{min} = 0.9^{+0.05}_{-0.1}$ Mpc. Apart from the larger 1σ uncertainty ranges due to the more complex models compared to the other clusters, the degeneracies between the parameters are relatively small. The low concentration of CL 1701+6414 seems inherent in the data and not to be a direct artifact of the presence of A 2246. Using the default model, we compute masses of $3.0^{+1.3}_{-1.2} \times 10^{14}$ M$\odot$ for CL 1701+6414 and $1.1^{+0.3}_{-0.2} \times 10^{14}$ M$\odot$ for A 2246. Table 7.8 in Sect. 7.3.9 summarises all models we tested (see Sect. 8.2 for the error analysis) with $\chi^2_{L3}$ depending on three parameters. The corresponding confidence contours are presented in Fig. B.16 in Appendix B.3.

7.3.8 Mass Modelling for CL 1641+4001

The $S$-statistics map of CL 1641+4001 – presented in Fig. 7.30 overlaid on the MEGACAM image – bears some resemblance to the CL 1701+6414 field. Here too, we observe several shear peaks, forming a connected structure of $> 20'$ extent. The ROSAT centre of CL 1641+4001 (big star symbol) is located within a plateau of $> 3\sigma$ significance in the $S$-statistics, as well as its BCG, 24' north-east of the ROSAT centre. Within this plateau, the 15'' mesh size grid cell giving the highest $S$-value is found 95'' north of the ROSAT coordinates (green square with error bars in Fig. 7.30).

Beside CL 1641+4001, the only other known galaxy cluster in the vicinity of the shear peaks is SDSS-C4-DR3 3628 at $z = 0.032$. This object was identified in the SDSS Data Release 3 (DR3), using the “C4” cluster detection algorithm (Miller et al. 2005). However, it was published by von der Linden et al. (2007) who, in their studies of BCGs, also included DR3 objects not published by Miller et al. (2005). Our MEGACAM $r'$-band image shows two bright galaxies at the coordinates of SDSS-C4-DR3 3628 (small star symbol in Fig. 7.30) but gives no indication of a nearby cluster of galaxies. We notice that NED, at the same coordinates, also lists CGCG 224-092, a galaxy pair, at the same $z = 0.032$. Nevertheless, inspection of the CHANDRA image shows extended X-ray emission at these coordinates, indicative of a deep gravitational potential.

Both plots in Fig. 7.21 show the shear profile around the lensing centre of CL 1641+4001. The $\langle \epsilon_t(\theta) \rangle$ profile is flat, with a positive average in all bins and the most significant positive signal at $\sim 9'$ distance from the cluster centre. In the innermost two bins ($\theta < 3''33$), $\langle \epsilon_t(\theta) \rangle$ is of similar amplitude as the tangential component, but consistent with zero at the 1σ level. In the upper plot of Fig. 7.21, we present the best-fit one-cluster model, assuming $z = 0.46$, implying $\langle D_{ds}/D_s \rangle = 0.381$ (Table 6.4). We obtain a goodness-of-fit of $\chi^2/\nu_{dof} = 10988/10889 \approx 1.01$ and
Figure 7.21: Tangential shear profile around CL 1641+4001 assuming a single cluster at $z = 0.46$ (upper panel) and two clusters at $z = 0.46$ and $z = 0.032$, respectively (lower panel). The symbols in the upper panel are the same as in Fig. 7.12, the ones in the lower panel the same as in Fig. 7.18.
Figure 7.22: Confidence contours (99.73%, 95.4%, and 68.3%) and cluster parameters minimising $\chi^2_L$ (Eq. 6.12) for four models of CL 1641+4001. Solid contours and the filled circle denote the default model, centred on the strongest lensing peak. Dashed contours and a diamond mark the model centred on the second-strongest lensing peak. Models centred on the ROSAT centre and the BCG are given by dot-dashed contours and a square, and triple-dot dashed contours and a triangle, respectively.

$r_{200}^{\text{fit}} = 1.44 \pm 0.26$ Mpc and $c_{\text{NFW}}^{\text{fit}} = 0.3 \pm 0.5$. Similar to the single-cluster fit of CL 1701+6414, the very low $c_{\text{NFW}}^{\text{fit}}$ is consistent with zero, reflecting the flat shear profile.

Therefore, we test a two-cluster model, introducing a second component at the redshift of SDSS-C4-DR3 3628, with $\langle D_{\text{ls}}/D_s \rangle = 0.940$ calculated in the same way as the other geometric factors. We choose the position of the second-highest shear peak ($S = 3.95$; green triangle in Fig. 7.30) as the centre of the secondary component. The offset of $\sim 3^\prime$ to the coordinates of SDSS-C4-DR3 3628 is justified by the large mask at the latter position. The two-cluster fit yields $\chi^2/\nu_{\text{dof}} = 22640/22658 = 1.00$ and cluster parameters $r_{p,200}^{\text{fit}} = 1.10 \pm 0.33$ Mpc and $c_{\text{NFW}}^{\text{fit}} = 1.2 \pm 1.7$ for CL 1641+4001 and $r_{s,200}^{\text{fit}} = 0.88 \pm 0.35$ Mpc and $c_{s,\text{NFW}}^{\text{fit}} = 6.4 \pm 1.0$ for the secondary. The best-fit shear profiles for the two-cluster model are shown in the lower plot of Fig. 7.21, in the same way as the two-cluster model in Fig. 7.18. The modelled tangential component $\langle g_t \rangle$ around CL 1641+4001 for the inner bins agrees well with the data $\langle e_t \rangle$. The problem with the two-cluster model lies in the mass estimate of $8.5 \times 10^{13}$ M$_{\odot}$ given by Eq. (6.7) for SDSS-C4-DR3 3628, the mass of a fully fledged cluster. This estimate is in stark disagreement with the absence of a massive, nearby cluster from our Megacam image. Which, against all odds, would have had to be missed by all but one cluster surveys hitherto! Hence, we deem it unlikely that the complex structure in the $S$-map of CL 1641+4001 bears a significant contribution from the $z = 0.032$ structure: In order for it to
cause the observed shear, the necessary mass would have to be too large to be consistent with the observed light.

We prefer the hypothesis that the shear is caused by a complex structure at the redshift of CL 1641+4001, although its X-ray morphology does not hint at a merger (Vikhlinin et al. 2009a). Being aware of the shortcomings of a single NFW model in this case, we return to the model presented in the upper panel of Fig. 7.21. We plan to conduct a more detailed analysis of CL 1641+4001, including a \(\kappa\) reconstruction.

In our default model for the analysis of the \(r_{200}\)-\(c_{\text{NFW}}\)-grid, we consider all sources at separation \(\theta < 16.67\) from the shear peak of CL 1641+4001. We obtain a minimum of \(\chi^2\) for \(r_{200}^{\min} = 1.28^{+0.21}_{-0.22}\) Mpc and \(c_{\text{NFW}}^{\min} = 0.3^{+0.7}_{-0.3}\). These results are illustrated by the filled circle and solid contours in Fig. 7.22. The very low concentration parameter is consistent with the one-cluster fit result. Cautioning the limitations of our model, we obtain a mass estimate of \(4.1^{+2.4}_{-1.8} \times 10^{14} M_\odot\).

Interestingly, choosing the secondary shear peak as a centre yields similar cluster parameters (Table 7.9 in Sect. 7.3.9 and diamond and dashed contours in Fig. 7.22). Models centred on the Ros\(\varpi\) centre (square and dot-dashed contours) or BCG (triangle and triple-dot dashed contours) give lower cluster masses and also even lower values for \(c_{\text{NFW}}\). Table 7.9 compiles the parameters obtained in all tested cases. Confidence contours for the models evaluated in the error analysis (Sect. 8.2) are given in Fig. B.15 in Appendix B.3.

### 7.3.9 Tabular Overview of Cluster Parameters

Tables 7.3 to 7.9 summarise the cluster parameters \(r_{200}^{\min}\) and \(c_{\text{NFW}}^{\min}\) for all tested models of the seven clusters presented in this Chapter. Following the layout of Table 6.7 for CL 0030+2618, we show the mass \(M_{200}\) (Eq. 6.7) for each model and also list the ratio \(\mu\) to the mass \(M_{200}^{\text{def}}\) obtained for the default model. See Tables 7.2 and 8.1 for comparisons between the cluster detections and masses.

Table 7.3: Like Table 6.7, but for CL 0159+0030 (Sect. 7.3.2). The default model includes all sources at separations \(0' < \theta < 13:33\) around the Ros\(\varpi\) centre, offset by 23\(\varpi\) from the lensing centre. The default model includes correction for contamination by cluster members. (Sect. 7.3.1).

<table>
<thead>
<tr>
<th>Model</th>
<th>(r_{200}^{\min}/\text{Mpc})</th>
<th>(c_{\text{NFW}}^{\min})</th>
<th>(M_{200}(r_{200}^{\min}))</th>
<th>(\mu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>1.44^{+0.18}_{-0.17}</td>
<td>9.2^{+7.6}_{-7.5}</td>
<td>5.4^{+2.7}<em>{-2.3} \times 10^{14} M</em>\odot</td>
<td>--</td>
</tr>
<tr>
<td>(\theta_{\text{max}} = 15')</td>
<td>1.38^{+0.21}_{-0.22}</td>
<td>&gt; 16</td>
<td>4.8^{+2.3}<em>{-2.0} \times 10^{14} M</em>\odot</td>
<td>0.88</td>
</tr>
<tr>
<td>no contam. corr.</td>
<td>1.39^{+0.21}_{-0.22}</td>
<td>8.55^{+7.45}_{-9.7}</td>
<td>4.9^{+2.0}<em>{-1.9} \times 10^{14} M</em>\odot</td>
<td>0.90</td>
</tr>
<tr>
<td>max((</td>
<td>\epsilon</td>
<td>)) = 1.0</td>
<td>1.51^{+0.17}_{-0.20}</td>
<td>11.9^{+9.7}_{-9.7}</td>
</tr>
<tr>
<td>max((</td>
<td>\epsilon</td>
<td>)) = 10^4</td>
<td>1.51^{+0.20}_{-0.24}</td>
<td>&gt; 16</td>
</tr>
<tr>
<td>(f_0 = 0.97)</td>
<td>1.40^{+0.24}_{-0.22}</td>
<td>9.05^{+7.55}_{-7.8}</td>
<td>5.0^{+2.1}<em>{-2.0} \times 10^{14} M</em>\odot</td>
<td>0.92</td>
</tr>
<tr>
<td>(f_0 = 1.13)</td>
<td>1.45^{+0.21}_{-0.20}</td>
<td>9.45^{+7.55}_{-7.8}</td>
<td>5.5^{+2.1}<em>{-2.0} \times 10^{14} M</em>\odot</td>
<td>1.02</td>
</tr>
<tr>
<td>(\langle D_{\text{ds}}/D_s \rangle = 0.424)</td>
<td>1.47^{+0.22}_{-0.22}</td>
<td>9.45^{+7.55}_{-7.8}</td>
<td>5.8^{+2.3}<em>{-2.1} \times 10^{14} M</em>\odot</td>
<td>1.06</td>
</tr>
<tr>
<td>(\langle D_{\text{ds}}/D_s \rangle = 0.470)</td>
<td>1.41^{+0.22}_{-0.22}</td>
<td>9.0^{+7.55}_{-7.8}</td>
<td>5.1^{+2.1}<em>{-2.0} \times 10^{14} M</em>\odot</td>
<td>0.94</td>
</tr>
</tbody>
</table>
Table 7.4: Like Table 6.7, but for CL 0809+2811 (Sect. 7.3.3). The default model includes all sources at separations $0'5 < \theta < 15'$ around the lensing centre centre, offset by 79$''$ from the Rosat centre. The default model includes correction for contamination by cluster members. (Sect. 7.3.1).

<table>
<thead>
<tr>
<th>Model</th>
<th>$r_{\text{min}}^\text{Mpc}/\text{Mpc}$</th>
<th>$r_{\text{NFW}}^\text{Mpc}$</th>
<th>$M_{200}(r_{\text{min}}^\text{Mpc})$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>$1.83^{+0.16}_{-0.19}$</td>
<td>$3.7^{+3.1}_{-2.2}$</td>
<td>$11.2^{+3.2}<em>{-3.0} \times 10^{14} M</em>\odot$</td>
<td>–</td>
</tr>
<tr>
<td>$\theta_{\text{min}} = 0'$</td>
<td>$1.83^{+0.16}_{-0.18}$</td>
<td>$3.85^{+2.2}_{-2.2}$</td>
<td>$11.2^{+3.2}<em>{-3.0} \times 10^{14} M</em>\odot$</td>
<td>1.00</td>
</tr>
<tr>
<td>no contam. corr.</td>
<td>$1.76^{+0.16}_{-0.18}$</td>
<td>$3.45^{+4.7}_{-2.05}$</td>
<td>$10.0^{+2.8}<em>{-3.0} \times 10^{14} M</em>\odot$</td>
<td>0.89</td>
</tr>
<tr>
<td>centred on Rosat peak</td>
<td>$1.71^{+0.01}_{-0.01}$</td>
<td>$1.25^{+2.3}_{-1.9}$</td>
<td>$9.2^{+3.7}<em>{-3.0} \times 10^{14} M</em>\odot$</td>
<td>0.82</td>
</tr>
<tr>
<td>max(</td>
<td>k</td>
<td>) = 1.0</td>
<td>$1.79^{+0.20}_{-0.23}$</td>
<td>$1.95^{+2.85}_{-1.39}$</td>
</tr>
<tr>
<td>max(</td>
<td>k</td>
<td>) = $10^4$</td>
<td>$1.87^{+0.28}_{-0.28}$</td>
<td>$1.2^{+2.3}_{-1.39}$</td>
</tr>
<tr>
<td>$f_0 = 0.95$</td>
<td>$1.75^{+0.16}_{-0.17}$</td>
<td>$3.7^{+5.25}_{-2.35}$</td>
<td>$9.8^{+3.6}<em>{-3.0} \times 10^{14} M</em>\odot$</td>
<td>0.87</td>
</tr>
<tr>
<td>$f_0 = 1.13$</td>
<td>$1.85^{+0.19}_{-0.19}$</td>
<td>$3.8^{+5.33}_{-2.31}$</td>
<td>$11.6^{+3.3}<em>{-2.8} \times 10^{14} M</em>\odot$</td>
<td>1.03</td>
</tr>
<tr>
<td>$\langle D_{\text{ds}}/D_s \rangle = 0.414$</td>
<td>$1.87^{+0.19}_{-0.19}$</td>
<td>$3.85^{+5.33}_{-2.31}$</td>
<td>$12.0^{+3.3}<em>{-2.8} \times 10^{14} M</em>\odot$</td>
<td>1.07</td>
</tr>
<tr>
<td>$\langle D_{\text{ds}}/D_s \rangle = 0.460$</td>
<td>$1.78^{+0.18}_{-0.18}$</td>
<td>$3.7^{+5.25}_{-2.25}$</td>
<td>$10.4^{+3.3}<em>{-2.8} \times 10^{14} M</em>\odot$</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Table 7.5: Like Table 6.7, but for CL 0230+1836 (Sect. 7.3.4). The default model includes all sources at separations $0' < \theta < 13'33$ around the lensing centre centre, offset by 20$''$ from the Rosat centre, and by 32$''$ from the likely BCG. The default model includes correction for contamination by cluster members. (Sect. 7.3.1).

<table>
<thead>
<tr>
<th>Model</th>
<th>$r_{\text{min}}^\text{Mpc}/\text{Mpc}$</th>
<th>$r_{\text{NFW}}^\text{Mpc}$</th>
<th>$M_{200}(r_{\text{min}}^\text{Mpc})$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>$1.40^{+0.24}_{-0.29}$</td>
<td>$3.2^{+1.7}_{-1.6}$</td>
<td>$8.1^{+4.9}<em>{-4.4} \times 10^{14} M</em>\odot$</td>
<td>–</td>
</tr>
<tr>
<td>$\theta_{\text{min}} = 0'5$</td>
<td>$1.41^{+0.22}_{-0.27}$</td>
<td>$4.8^{+4.4}_{-2.65}$</td>
<td>$8.3^{+4.9}<em>{-4.4} \times 10^{14} M</em>\odot$</td>
<td>1.02</td>
</tr>
<tr>
<td>$m_{\text{bright}} = m_{\text{bright}} = 23.4$</td>
<td>$1.51^{+0.23}_{-0.29}$</td>
<td>$3.2^{+1.65}_{-1.45}$</td>
<td>$10.2^{+5.7}<em>{-4.3} \times 10^{14} M</em>\odot$</td>
<td>1.26</td>
</tr>
<tr>
<td>centred on BCG</td>
<td>$1.35^{+0.28}_{-0.35}$</td>
<td>$2.05^{+1.55}_{-1.11}$</td>
<td>$7.3^{+5.3}<em>{-4.3} \times 10^{14} M</em>\odot$</td>
<td>0.90</td>
</tr>
<tr>
<td>no contam. corr.</td>
<td>$1.36^{+0.23}_{-0.29}$</td>
<td>$2.7^{+1.6}_{-1.1}$</td>
<td>$7.4^{+4.8}<em>{-4.3} \times 10^{14} M</em>\odot$</td>
<td>0.92</td>
</tr>
<tr>
<td>max(</td>
<td>k</td>
<td>) = 1.0</td>
<td>$1.47^{+0.27}_{-0.34}$</td>
<td>$2.5^{+1.8}_{-1.4}$</td>
</tr>
<tr>
<td>max(</td>
<td>k</td>
<td>) = $10^4$</td>
<td>$1.49^{+0.28}_{-0.34}$</td>
<td>$2.85^{+2.05}_{-1.65}$</td>
</tr>
<tr>
<td>$f_0 = 0.73$</td>
<td>$1.22^{+0.20}_{-0.24}$</td>
<td>$2.9^{+1.85}_{-1.4}$</td>
<td>$5.4^{+3.1}<em>{-2.6} \times 10^{14} M</em>\odot$</td>
<td>0.66</td>
</tr>
<tr>
<td>$f_0 = 1.13$</td>
<td>$1.42^{+0.25}_{-0.30}$</td>
<td>$3.25^{+1.95}_{-1.65}$</td>
<td>$8.5^{+5.3}<em>{-4.3} \times 10^{14} M</em>\odot$</td>
<td>1.04</td>
</tr>
<tr>
<td>$\langle D_{\text{ds}}/D_s \rangle = 0.148$</td>
<td>$1.49^{+0.25}_{-0.31}$</td>
<td>$3.4^{+1.95}_{-1.65}$</td>
<td>$9.8^{+5.3}<em>{-4.3} \times 10^{14} M</em>\odot$</td>
<td>1.21</td>
</tr>
<tr>
<td>$\langle D_{\text{ds}}/D_s \rangle = 0.188$</td>
<td>$1.33^{+0.21}_{-0.28}$</td>
<td>$3.05^{+1.85}_{-1.35}$</td>
<td>$6.2^{+4.3}<em>{-3.3} \times 10^{14} M</em>\odot$</td>
<td>0.90</td>
</tr>
</tbody>
</table>
Table 7.6: Like Table 6.7, but for CL 1357+6232 (Sect. 7.3.5). The default model includes all sources at separations $0' < \theta < 15'$ around the lensing centre, offset by 50'' from the Rosar centre. The default model of this single-band cluster includes no correction for contamination by cluster members.

<table>
<thead>
<tr>
<th>Model</th>
<th>$r_{200}^{\text{min}}$/Mpc</th>
<th>$c_{\text{NFW}}^{\text{min}}$</th>
<th>$M_{200}(c_{\text{NFW}}^{\text{min}})$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>$1.18^{+0.17}_{-0.20}$</td>
<td>$2.8^{+2.85}_{-1.28}$</td>
<td>$3.5^{+1.7}<em>{-0.97} \times 10^{14}$ M$</em>\odot$</td>
<td>--</td>
</tr>
<tr>
<td>$0'5 \leq \theta \leq 15'$</td>
<td>$1.18^{+0.17}_{-0.18}$</td>
<td>$3.6^{+3.25}_{-1.88}$</td>
<td>$3.5^{+1.7}<em>{-0.97} \times 10^{14}$ M$</em>\odot$</td>
<td>1.00</td>
</tr>
<tr>
<td>centred on BCG</td>
<td>$1.11^{+0.18}_{-0.20}$</td>
<td>$3.1^{+2.45}_{-1.41}$</td>
<td>$2.9^{+1.9}<em>{-1.2} \times 10^{14}$ M$</em>\odot$</td>
<td>0.83</td>
</tr>
<tr>
<td>centred on Rosar peak</td>
<td>$1.05^{+0.14}_{-0.17}$</td>
<td>$4.8^{+4.35}_{-3.65}$</td>
<td>$2.5^{+3.1}<em>{-1.9} \times 10^{14}$ M$</em>\odot$</td>
<td>0.70</td>
</tr>
<tr>
<td>max($</td>
<td>e</td>
<td>$) = 1.0</td>
<td>$1.11^{+0.19}_{-0.23}$</td>
<td>$2.6^{+2.65}_{-1.35}$</td>
</tr>
<tr>
<td>max($</td>
<td>e</td>
<td>$) = $10^4$</td>
<td>$1.01^{+0.22}_{-0.29}$</td>
<td>$3.2^{+3.35}_{-2.46}$</td>
</tr>
<tr>
<td>$f_0 = 0.86$</td>
<td>$1.08^{+0.16}_{-0.17}$</td>
<td>$2.6^{+2.65}_{-1.35}$</td>
<td>$2.7^{+1.4}<em>{-1.2} \times 10^{14}$ M$</em>\odot$</td>
<td>0.77</td>
</tr>
<tr>
<td>$f_0 = 1.13$</td>
<td>$1.19^{+0.18}_{-0.20}$</td>
<td>$2.8^{+2.85}_{-1.33}$</td>
<td>$3.6^{+3.1}<em>{-2.1} \times 10^{14}$ M$</em>\odot$</td>
<td>1.03</td>
</tr>
<tr>
<td>$\langle D_{ls}/D_s \rangle = 0.300$</td>
<td>$1.22^{+0.21}_{-0.21}$</td>
<td>$2.9^{+2.9}_{-1.33}$</td>
<td>$3.9^{+3.1}<em>{-2.1} \times 10^{14}$ M$</em>\odot$</td>
<td>1.11</td>
</tr>
<tr>
<td>$\langle D_{ls}/D_s \rangle = 0.348$</td>
<td>$1.14^{+0.19}_{-0.18}$</td>
<td>$2.7^{+2.7}_{-1.2}$</td>
<td>$3.2^{+2.1}<em>{-1.3} \times 10^{14}$ M$</em>\odot$</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Table 7.7: Like Table 6.7, but for CL 1416+4446 (Sect. 7.3.6). The default model includes all sources at separations $0'5 < \theta < 14'$ around the lensing centre, offset by 19'' from the Rosar centre. The default model of this single-band cluster includes no correction for contamination by cluster members.

<table>
<thead>
<tr>
<th>Model</th>
<th>$r_{200}^{\text{min}}$/Mpc</th>
<th>$c_{\text{NFW}}^{\text{min}}$</th>
<th>$M_{200}(c_{\text{NFW}}^{\text{min}})$</th>
<th>$\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>$0.99^{+0.14}_{-0.19}$</td>
<td>$4.9^{+2.9}_{-2.95}$</td>
<td>$1.8^{+0.9}<em>{-0.7} \times 10^{14}$ M$</em>\odot$</td>
<td>--</td>
</tr>
<tr>
<td>$\theta_{\text{min}} = 0'$</td>
<td>$0.95^{+0.17}_{-0.20}$</td>
<td>$2.1^{+2.15}_{-1.18}$</td>
<td>$1.6^{+0.8}<em>{-0.7} \times 10^{14}$ M$</em>\odot$</td>
<td>0.88</td>
</tr>
<tr>
<td>centred on Rosar peak</td>
<td>$0.97^{+0.13}_{-0.18}$</td>
<td>$5.2^{+5.25}_{-3.35}$</td>
<td>$1.7^{+0.8}<em>{-0.7} \times 10^{14}$ M$</em>\odot$</td>
<td>0.94</td>
</tr>
<tr>
<td>max($</td>
<td>e</td>
<td>$) = $10^4$</td>
<td>$1.03^{+0.18}_{-0.17}$</td>
<td>$4.2^{+4.25}_{-2.21}$</td>
</tr>
<tr>
<td>$f_0 = 0.92$</td>
<td>$1.08^{+0.16}_{-0.18}$</td>
<td>$4.4^{+4.45}_{-2.65}$</td>
<td>$2.3^{+1.2}<em>{-1.0} \times 10^{14}$ M$</em>\odot$</td>
<td>1.30</td>
</tr>
<tr>
<td>$f_0 = 1.13$</td>
<td>$1.01^{+0.14}_{-0.17}$</td>
<td>$4.9^{+4.95}_{-2.95}$</td>
<td>$1.9^{+0.9}<em>{-0.8} \times 10^{14}$ M$</em>\odot$</td>
<td>1.06</td>
</tr>
<tr>
<td>$\langle D_{ls}/D_s \rangle = 0.414$</td>
<td>$1.02^{+0.14}_{-0.17}$</td>
<td>$4.9^{+4.95}_{-2.95}$</td>
<td>$2.0^{+0.9}<em>{-0.8} \times 10^{14}$ M$</em>\odot$</td>
<td>1.09</td>
</tr>
<tr>
<td>$\langle D_{ls}/D_s \rangle = 0.460$</td>
<td>$0.97^{+0.14}_{-0.18}$</td>
<td>$4.7^{+4.75}_{-2.85}$</td>
<td>$1.7^{+0.8}<em>{-0.8} \times 10^{14}$ M$</em>\odot$</td>
<td>0.94</td>
</tr>
</tbody>
</table>
Table 7.8: Like Table 6.7, but for the CL 1701+6414 field in which two clusters, CL 1701+6414 and A 2246, are modelled (Sect. 7.3.7). In addition to the parameters of CL 1701+6414, the radius \( r_{200} \) and the corresponding mass inferred for A 2246 are given. The two-cluster model includes the complete radial range of the lensing catalogue and is centred on the lensing peak of CL 1701+6414, separated by 66" from its Rosat peak. No correction for contamination by cluster members is applied in this single-band field.

<table>
<thead>
<tr>
<th>Model</th>
<th>( r_{\min_{200}}^{1701+6414} ) /Mpc</th>
<th>( r_{\min_{NFW}}^{1701+6414} )</th>
<th>( M_{200}^{1701+6414}(r_{\min_{200}}^{1701+6414}) ) ( \mu )</th>
<th>( r_{\min_{s,200}}^{2246} ) /Mpc</th>
<th>( M_{200}^{2246}(r_{\min_{s,200}}^{2246}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>1.15^{+0.19}_{-0.21}</td>
<td>0.6^{+1.6}_{-1.6}</td>
<td>3.0^{+1.7}<em>{-1.7} \times 10^{14} \text{M}</em>\odot</td>
<td>–</td>
<td>0.9^{+0.05}_{-0.05}</td>
</tr>
<tr>
<td>cent. on Rosat peak</td>
<td>1.04^{+0.20}_{-0.27}</td>
<td>&lt;0.2</td>
<td>2.2^{+1.3}<em>{-1.3} \times 10^{14} \text{M}</em>\odot</td>
<td>0.74</td>
<td>0.85^{+0.05}_{-0.05}</td>
</tr>
<tr>
<td>max((</td>
<td>e</td>
<td>)) = 1.0</td>
<td>1.07^{+0.22}_{-0.22}</td>
<td>0.4^{+2.0}_{-0.2}</td>
<td>2.4^{+1.4}<em>{-1.4} \times 10^{14} \text{M}</em>\odot</td>
</tr>
<tr>
<td>max((</td>
<td>e</td>
<td>)) = 10^4</td>
<td>1.11^{+0.22}_{-0.35}</td>
<td>0.8^{+1.8}_{-0.4}</td>
<td>2.7^{+1.5}<em>{-1.5} \times 10^{14} \text{M}</em>\odot</td>
</tr>
<tr>
<td>( f_0 = 0.92 )</td>
<td>1.03^{+0.18}_{-0.19}</td>
<td>0.4^{+1.6}_{-0.2}</td>
<td>2.1^{+1.9}<em>{-1.9} \times 10^{14} \text{M}</em>\odot</td>
<td>0.72</td>
<td>0.85^{+0.05}_{-0.05}</td>
</tr>
<tr>
<td>( f_0 = 1.13 )</td>
<td>1.18^{+0.19}_{-0.19}</td>
<td>0.6^{+0.6}_{-0.6}</td>
<td>3.2^{+1.5}<em>{-1.5} \times 10^{14} \text{M}</em>\odot</td>
<td>1.08</td>
<td>0.9^{+0.05}_{-0.05}</td>
</tr>
<tr>
<td>( \langle D_{bs}/D_s \rangle = 0.357 )</td>
<td>1.20^{+0.19}_{-0.19}</td>
<td>0.6^{+1.6}_{-1.6}</td>
<td>3.4^{+1.5}<em>{-1.5} \times 10^{14} \text{M}</em>\odot</td>
<td>1.14</td>
<td>0.9^{+0.05}_{-0.05}</td>
</tr>
<tr>
<td>( \langle D_{bs}/D_s \rangle = 0.405 )</td>
<td>1.11^{+0.12}_{-0.20}</td>
<td>0.6^{+1.6}_{-1.6}</td>
<td>2.7^{+1.5}<em>{-1.5} \times 10^{14} \text{M}</em>\odot</td>
<td>0.90</td>
<td>0.9^{+0.05}_{-0.05}</td>
</tr>
</tbody>
</table>

Table 7.9: Like Table 6.7, but for the CL 1641+4001 field (Sect. 7.3.8), in which we, despite a complicated shear field, favour a single-cluster model. The default model includes all sources at separations \( 0' < \theta < 16:66 \) around the lensing centre, offset by 95" from the Rosat centre. No correction for contamination by cluster members is applied in this single-band field.

<table>
<thead>
<tr>
<th>Model</th>
<th>( r_{\min_{200}}^{\text{min}} ) /Mpc</th>
<th>( r_{\min_{NFW}}^{\text{min}} )</th>
<th>( M_{200}^{\text{min}}(r_{\min_{200}}^{\text{min}}) )</th>
<th>( M_{200}^{\text{min}}(r_{\min_{s,200}}^{\text{min}}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>1.28^{+0.21}_{-0.21}</td>
<td>0.3^{+0.7}_{-0.3}</td>
<td>4.1^{+2.4}<em>{-1.8} \times 10^{14} \text{M}</em>\odot</td>
<td>–</td>
</tr>
<tr>
<td>( \theta_{\min} = 30' )</td>
<td>1.28^{+0.23}_{-0.23}</td>
<td>0.3^{+0.6}_{-0.3}</td>
<td>4.1^{+2.4}<em>{-1.8} \times 10^{14} \text{M}</em>\odot</td>
<td>1.00</td>
</tr>
<tr>
<td>centred on Rosat peak</td>
<td>1.12^{+0.23}_{-0.23}</td>
<td>&lt;0.05</td>
<td>2.8^{+2.2}<em>{-1.2} \times 10^{14} \text{M}</em>\odot</td>
<td>0.67</td>
</tr>
<tr>
<td>centred on BCG</td>
<td>1.14^{+0.25}_{-0.25}</td>
<td>&lt;0.05</td>
<td>2.9^{+2.3}<em>{-1.3} \times 10^{14} \text{M}</em>\odot</td>
<td>0.71</td>
</tr>
<tr>
<td>centred on 2.5-peak</td>
<td>1.25^{+0.24}_{-0.24}</td>
<td>0.3^{+0.7}_{-0.3}</td>
<td>3.8^{+2.3}<em>{-1.3} \times 10^{14} \text{M}</em>\odot</td>
<td>0.93</td>
</tr>
<tr>
<td>max((</td>
<td>e</td>
<td>)) = 1.0</td>
<td>1.33^{+0.33}_{-0.33}</td>
<td>0.3^{+0.7}_{-0.3}</td>
</tr>
<tr>
<td>max((</td>
<td>e</td>
<td>)) = 10^4</td>
<td>1.16^{+0.29}_{-0.29}</td>
<td>0.75^{+1.65}_{-0.55}</td>
</tr>
<tr>
<td>( f_0 = 0.93 )</td>
<td>1.19^{+0.19}_{-0.19}</td>
<td>0.3^{+0.6}_{-0.3}</td>
<td>3.3^{+1.9}<em>{-1.9} \times 10^{14} \text{M}</em>\odot</td>
<td>0.80</td>
</tr>
<tr>
<td>( f_0 = 1.13 )</td>
<td>1.31^{+0.23}_{-0.23}</td>
<td>0.3^{+0.7}_{-0.3}</td>
<td>4.4^{+2.4}<em>{-2.4} \times 10^{14} \text{M}</em>\odot</td>
<td>1.07</td>
</tr>
<tr>
<td>( \langle D_{bs}/D_s \rangle = 0.357 )</td>
<td>1.36^{+0.23}_{-0.23}</td>
<td>0.3^{+0.7}_{-0.3}</td>
<td>5.0^{+2.8}<em>{-2.8} \times 10^{14} \text{M}</em>\odot</td>
<td>1.20</td>
</tr>
<tr>
<td>( \langle D_{bs}/D_s \rangle = 0.405 )</td>
<td>1.23^{+0.20}_{-0.21}</td>
<td>0.3^{+0.6}_{-0.3}</td>
<td>3.7^{+2.1}<em>{-1.6} \times 10^{14} \text{M}</em>\odot</td>
<td>0.89</td>
</tr>
</tbody>
</table>
7.4 Aperture Mass Significance Maps

Figure 7.23: Aperture mass significance map of CL 0159+0030. The figure shows the central, most interesting region of the Megacam $r'$-band image, overlaid with excision masks (thin red lines, Sect. 5.1.3) and $S$-contours (thicker orange lines). Contour levels start at $S = 0.5$, with an increment of $\Delta S = 0.5$. The cell in the grid of 15'' mesh size with the highest $S$-value is marked by a green square with error bars showing its extent. A star symbol denotes the Rosat centre of CL 0159+0030. Beside the square masks related to the source density counts, the figure shows examples of octagonal masks around saturated stars and manually defined masks for asteroid tracks and a saturated galaxy.
Figure 7.24: Aperture mass map of CL 0809+2811, overlaid on the central, most interesting region of the MEGACAM $r'$-band image. The lines and symbols are the same as in Fig. 7.23.
Figure 7.25: Aperture mass map of CL 0230+1836, overlaid on the central region, overlaid on the central, of the Megacam $r'$-band image. The lines and symbols are the same as in Fig. 7.23.
Figure 7.26: Aperture mass map of CL 1357+6232, overlaid on the most interesting region of the Megacam $r'$-band image. The lines and symbols are the same as in Fig. 7.23.
Figure 7.27: Aperture mass map of CL 1416+4446, overlaid on the most interesting region of the Megacam $r'$-band image. The lines and symbols are the same as in Fig. 7.23. In addition, two small four-pointed star symbols mark the coordinates of two further clusters, which we discuss in Sect. 8.1.3.
Figure 7.28: Aperture mass map of CL 1701+6414, overlaid on the central, most interesting region of the MegaCam $r'$-band image. The lines and symbols are the same as in Fig. 7.23. In addition to the eight-pointed star symbol denoting the Rosat centre of CL 1701+6414, a big four-pointed star symbol marks the position of Abell 2246, and three smaller ones the positions of VMF 191 ($\alpha_{2000} = 17^h01^m46^s, \delta_{2000} = +64^\circ21'15''$), VMF 192 ($\alpha_{2000} = 17^h02^m13^s, \delta_{2000} = +64^\circ20'20''$), and RX J1702+6407 ($\alpha_{2000} = 17^h02^m01^s, \delta_{2000} = +64^\circ07'39''$), respectively. All of these clusters are X-ray sources detected with Rosat. Inspection of the Rosat image does not show any obvious, strong extended emission at the position of the $3.6\sigma$ shear peak south-west of A 2246.
Figure 7.29: Zoomed version of Fig. 7.28, showing the BCG of CL 1701+6414, and, to the west of it and above the star symbol marking the ROSAT centre, the tentative strong lensing arc.
Figure 7.30: Aperture mass map of CL 1641+4001, overlaid on the central, most interesting region of the MEGACAM $r'$-band image. The lines and symbols are the same as in Fig. 7.23. In addition to the eight-pointed star symbol denoting the Rosat centre of CL 1641+4001, a four-pointed star symbol marks the coordinates of SDSS-C4-DR3 3628 (Sect. 7.3.8). Inspection of the CHANDRA image shows extended X-ray emission at these coordinates of SDSS-C4-DR3 3628, indicative of a deep gravitational potential.