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H_0 determinations via the S–Z & X–ray route

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Abstract. A new H_0 determination via the S–Z & X–ray route from cluster 0016+16 is presented. Potential sources of errors, in particular the effect of temperature profiles, are discussed.

1. Determining H_0

The principle of determining H_0 via the S–Z & X–ray route is well known – see e.g. Birkinshaw (2000). Briefly, a measurement of the S–Z effect, an X–ray image and a X–ray temperature are combined to determine the line-of-sight size of a cluster. This is then combined with a geometrical model to calibrate the distance scale, and hence estimate H_0.

2. Source Subtraction

The Cavendish group uses the Ryle telescope, an 8–element interferometer operating at 15GHz, to observe the S–Z effect. Short baselines, i.e. those less than 1.5kλ, are used to observe the S–Z decrement whilst baselines longer simultaneously observe point sources which would otherwise mask the S–Z signal. As discussed by Talyor (2000), point sources are present in the sky at 15GHz, and they are not necessarily even present in lower frequency surveys.

I have developed a new source subtraction algorithm that makes use of both the long and short baseline visibility data. A model of the sky is produced, parameterised by a King model of the cluster gas, and positions and fluxes of the point sources. The parameters for the King model are determined from X–ray observations and, apart from the overall normalization, held constant. An observation of the field is then simulated and the parameters (i.e. the source positions and fluxes, and the S–Z amplitude) varied to minimize χ^2 between model and data. This is an improvement on the old technique, in which only baselines longer than 1.5kλ are used to find and subtract point sources. Figure 1 shows the source-subtracted map of the S–Z effect in 0016+16, overlaid on a PSPC observation. Estimating H_0 from this cluster gives a value of $H_0 = 68^{+28}_{-20}$ km/s/Mpc. The errors here are solely due to the noise on the S–Z measurement.

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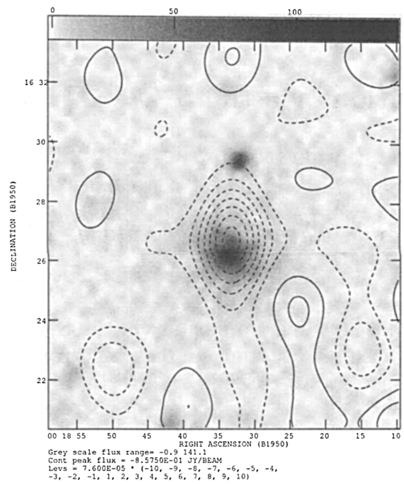

Figure 1. Radio source subtracted S–Z observation of 0016+16 with the Ryle (contours) and PSPC ROSAT image of the same (greyscale)

3. Errors

There are many potential sources of error in H_0 determination. The line-of-sight uncertainty can be largely eliminated with a suitably sized sample of clusters; 15 clusters are required for the uncertainty due to line-of-sight to be $\pm 6\%$.

The temperature profile is also important. If the temperature profile drops with increasing radius then the S–Z profile is more compact than in the isothermal case. When observed with an interferometer, the flux measured on the shortest baseline is then higher for a decreasing temperature profile if the central decrements are the same. As H_0 varies as the inverse of the measured S–Z decrement, H_0 will be biased low. Clearly this argument is reversed if the temperature increases with radius. Thus it is very important to constrain the actual temperature profiles in real clusters.

4. Conclusions

A new estimate of H_0 via the S–Z and X–ray route from 0016+16 has been found. Potential sources of errors are well understood. Temperature profiles in the clusters may be a problem, and need to be measured (e.g. with XMM or Chandra) to avoid bias.

References

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