The Hubble Constant and X-rays from Galaxy Clusters

X-RAY measurements and limits on the Coma and Virgo clusters of galaxies have been said to limit the mass of hot gas in them to 2% of the amount required for stabilization according to the virial theorem¹. Such a conclusion is strongly dependent on the value of the Hubble constant H_0 . The linear diameter of the cluster D and the cluster mass M , estimated by the virial theorem, each vary as H_0^{-1} . Therefore, the density ρ has the dependence $\rho \sim H_0^2$. The predicted X-ray flux F from this gas is $\sim \rho M/R^2$, where R is the distance to the cluster. R varies as H_0^{-1} . We therefore have the relation

$$F \sim H_0^3 \quad (1)$$

Meekins *et al.*¹ appear to have used the value $H_0 = 95 \text{ km s}^{-1} \text{ Mpc}^{-1}$ found by van den Bergh², because they took $R = 70 \text{ Mpc}$. If Abell's value³ $H_0 = 47$ is used, the predicted flux is reduced by a factor of 0.12. A reduction of H_0 to a value as low as 20 is not inconceivable. Although clumpiness increases F/M^2 , the presence of helium as a mass fraction f reduces F for fixed M in the ratio $(1 - \frac{1}{2}f)$.

Meekins *et al.* measured a flux of $0.03 \text{ photons cm}^{-2} \text{ s}^{-1}$ almost entirely in the range 3–17 Å, and from other wavelength channels were able to state that the gas temperature exceeds $8 \times 10^6 \text{ K}$. For a flat counter response I have determined from standard bremsstrahlung formulae⁴ that it would take $2.6 \times 10^{47} \text{ g}$ of hydrogen at this temperature, uniformly distributed in a sphere of diameter 4 Mpc at the adopted distance of 70 Mpc, to produce this flux. This is four times the mass limit given by Meekins *et al.*¹, and is in clear disagreement because they gave a diameter of 5 Mpc and the actual counter response rises as the bremsstrahlung spectrum falls. A recalculation by Dr Meekins (private communication) based on the original assumptions and actual counter efficiency has confirmed that the mass estimate is higher than originally stated and in fact is increased to $7 \times 10^{47} \text{ g}$. On this basis, a value

$$H_0 = 38 \text{ km s}^{-1} \text{ Mpc}^{-1} \quad (2)$$

would suffice to give agreement with the virial theorem for the Coma cluster. Those who are sure, as I am not, that clusters of galaxies are stabilized by ionized gas may interpret the X-ray measurement of Meekins *et al.* as a measurement of H_0 .

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¹ Meekins, J. F., Fritz, G., Chubb, T. A., Friedman, H., and Henry, R. C., *Nature*, **231**, 107 (1971).

² van den Bergh, S., *Bull. Amer. Astron. Soc.*, **2**, 223 (1970).

³ Abell, G. O., and Eastmond, S., *Bull. Amer. Astron. Soc.*, **2**, 179 (1970). See also de Vaucouleurs, G., *Ap. J.*, **159**, 435 (1970).

⁴ Allen, C. W., *Astrophysical Quantities*, second ed., 100 (The Athlone Press, London, 1962). (A factor Hz^{-1} must be supplied in the units for j_ν .)

Mercury in Water of the Tidal Thames

WE have developed a method for the determination of traces of mercury, and have applied it to the tidal reaches of the River Thames. This article reports our observations of the concentrations of mercury and its partition between dissolved forms and that adsorbed on suspended particulate matter.

There is a background concentration of about $0.02 \text{ } \mu\text{g/kg}$ mercury in natural waters^{1–3}, and some recent results⁴ showed values of 0.009 – $0.021 \text{ } \mu\text{g/l.}$ for essentially dissolved mercury in sea and river water. In regions of mercury mineralization⁵, however, up to $100 \text{ } \mu\text{g/kg}$ has been reported. Similar amounts are found as a result of industrial pollution¹. For this study we chose sampling sites ranging from river water at Teddington to seawater at Southend with intermediate stations at Woolwich and Gravesend. The effluent from the Northern Outfall Sewage Works which provides a major input into the Thames⁶ was also examined. To achieve uniform sampling conditions all samples were collected by officers of the Port of London Authority on one day (May 24, 1971) 0.5 h after the afternoon high water at each station. Mercury was determined in whole and in filtered water and the mercury associated with the particulate matter found by difference.

The concentration of mercury in filtered water was low in the river water at Teddington and the seawater at Southend, and higher at Woolwich and Gravesend (Table 1). The level of dissolved mercury in the Northern Outfall effluent ($0.515 \text{ } \mu\text{g/kg}$) suggests that some mercury may be held in solution as organic complexes. At all stations most of the mercury was associated with the particulate matter. In waters of high chloride concentration 96–98% of the total mercury was in this form, the proportion being lower in the river water (87%) and in the sewage effluent (82%). The concentration of mercury in the suspended particulate matter varied significantly with 1.8 mg/kg in the river water at Teddington, 9.6 mg/kg in the seawater and 4.3 and 4.9 mg/kg at Woolwich and Gravesend. The seawater may have been affected by effluent from the Southend outfall. Particulate matter in the Northern Outfall effluent contained 35 mg/kg mercury. The total concentration of mercury in the effluent ($2.85 \text{ } \mu\text{g/kg}$) was about sixty times that in the river water at Teddington but is comparable with the slightly below $1 \text{ } \mu\text{g/l.}$ ⁷ reported for the Hyperion outfall, Los Angeles. Thames estuary water is only slightly stratified⁶ indicating a high degree of mixing, and the outfall is sited and operated to achieve a rapid dilution of the effluent.

Surface water was collected in a plastic container and transferred immediately to acid washed screw cap polypropylene bottles. For total mercury determination about 200 g was used. For dissolved mercury about 1 kg of water was filtered by pressure through a Whatman GFC filter, the collecting bottle

Table 1 Concentration of Mercury in Thames River Water

Miles from London Bridge	Station	Cl^- (mg/l.)	Particulate matter (mg/kg)	Total	Mercury found ($\mu\text{g/kg}$)			Calculated levels of mercury on particulate matter	
					Dissolved	Difference		mg/kg	% of total
–18.5	Teddington	39	21.6	0.045	0.006	0.039	1.8	87	
9	Woolwich	3,610	73.1	0.328	0.013	0.315	4.3	96	
11.5	N. Outfall	142	66.0	2.85	0.515	2.34	35.5	82	
27	Gravesend	10,030	89.9	0.446	0.009	0.437	4.9	98	
43	Southend	16,480	8.2	0.082	0.003	0.079	9.6	96	