# THE DEPENDENCE ON MORPHOLOGY OF THE GAS CONTENT IN GALACTIC DISKS

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## Introduction

The classification S0 was introduced by Hubble to serve as a description of galaxies whose morphological characteristics seemed to lie between the disk-dominated spirals and the spheroidal elliptical systems. Since then there has been extensive discussion as to whether this classification sequence is also an evolutionary sequence. Many studies have focussed on a particular feature such as the luminosity profile, the bulge-to-disk ratio, or the nature of the interstellar matter, but the question of the evolution remains contentious.

Equally contentious is the question of the classification itself. For systems with well-developed disks there usually is no problem. Many spheroidal systems also are unambiguously classified as ellipticals in most catalogs. However, there are a number of early systems which have been reclassified following review using improved optical material. For example, Eder *et al.* (AJ, 102, 572, 1991) found that many of the S0 galaxies which are rich in neutral hydrogen have faint spiral features. The confusion about classification propagates into the discussion of the properties of early-type systems. Attempts to put the classification system on a quantitative basis have in general been unsuccessful.

Recently Sandage (private communication) has reviewed the classification of early systems and has defined a set of sub-classes for these objects. The S0 galaxies are divided into three groups, depending on the prominence of the disk. There are six subdivisions of Sa galaxies, depending upon the relative prominence of knots and other arm-like characteristics. We have explored the total gas content in these objects to see if there is a dependence on the galaxy morphology, as denoted by these new subclasses.

## The Gas Content of Early Galaxies

We will use the estimates of mass that have been tabulated in the survey of Roberts *et al.* (ApJS, 75, 751, 1991). The hydrogen mass is derived from the observed flux in the usual way. The estimate of the mass of molecular hydrogen is obtained from the CO flux assuming the conversion factor obtaining in Galactic clouds. The dust mass is derived from IRAS fluxes at 60 and 100 micron wavelengths, but is sensitively dependent upon the value of the dust temperature which is assumed.

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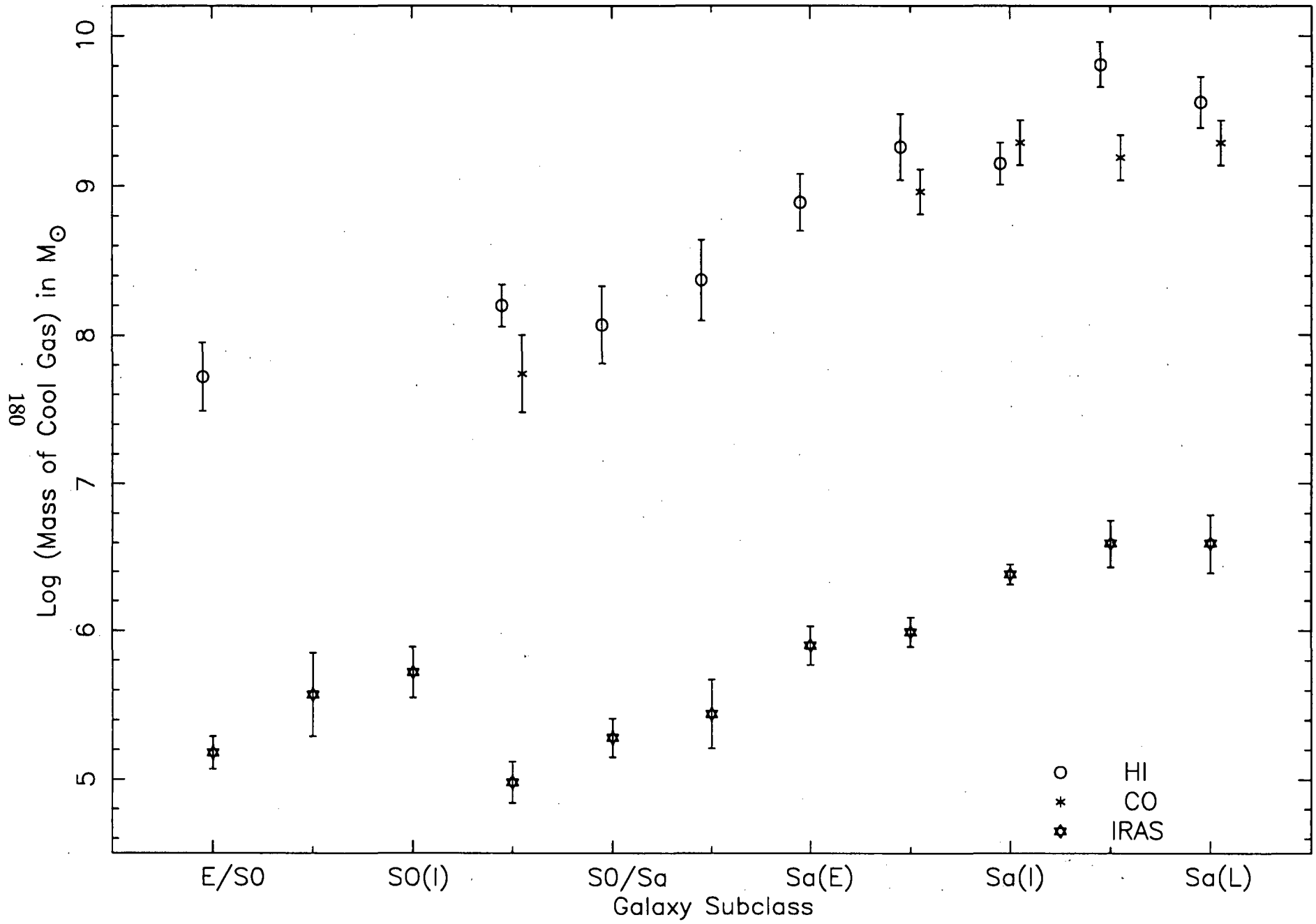
Figure 1 shows the mean value of each of the quantities, and an estimate of the uncertainty, as a function of galaxy type. The values have been obtained from both detections and upper limits by the use of survival analysis techniques. In general the later galaxies have significantly greater mass of cold gas than do the earlier types. The masses of atomic and molecular hydrogen are comparable, although it must be emphasized that the CO data are severely limited. The dust mass is lower than the gas mass, by a factor of between 500 and 1000, as is expected from earlier work (cf. Thronson *et al.* ApJ, 344, 747, 1989).

The masses of the individual components have been combined to provide an estimate of the total amount of cold gas in these galaxies. As might be anticipated from Figure 1, the amount of material increases markedly in going from the earliest Sa galaxies to the latest Sa galaxies. The mass of cold gas in S0's is much less, but there is little evidence of a trend with subclass. A striking feature of the gas content of the most pronounced S0 galaxies is the large dispersion. There are galaxies for which the upper limit to the cold gas is $10^8$ $M_\odot$, while there are galaxies of the same class having at least $3 \times 10^{10}$ $M_\odot$ of matter.

Various tests lead to the conclusion that there is little current star formation, at least of luminous blue stars. The average surface density is less than 0.5 $M_\odot$/sq.pc for all but the latest Sa galaxies, a value too low to support vigorous star formation (cf. Kennicutt, ApJ, 344, 685, 1989). Very few of the objects have the ratio of infrared to radio luminosity characteristic of star-forming galaxies. Finally, the infrared luminosity is low in comparison to that of later spiral galaxies.


Log (Mass of Cool Gas) in $M_{\odot}$
10
9
8
7
6
5
HI
CO
IRAS
E/S0
S0(I)
S0/Sa
Sa(E)
Sa(I)
Sa(L)
Galaxy Subclass