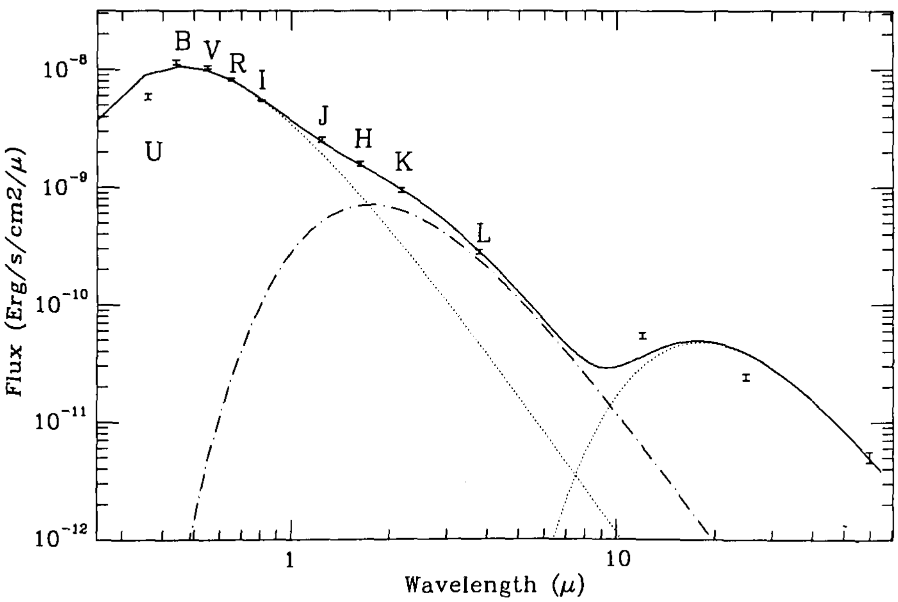

Figure 2: *Blackbody fit to the optical-infrared energy distribution of AK Sco. The three curves correspond to temperatures of 6,500, 1,600, and 160 K.*

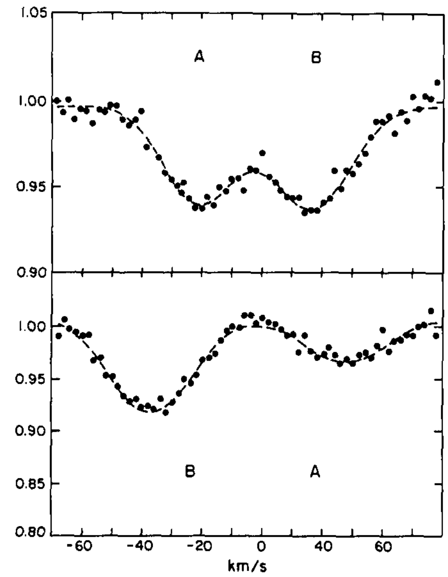

Figure 3: *Cross-correlation profiles for two CORAVEL observations (phases $0\overset{P}{.}23$ and $0\overset{P}{.}48$), separated by only 1.2 orbital cycles.*

presence of two dust components at approximate temperatures of 1,600 K and 160 K. The total energy emitted in these components amount to about half of that received from AK Sco, roughly consistent with the light loss at intermediate brightness levels.

Size of the Dust Clouds

We can obtain an order-of-magnitude estimate of the sizes of the two dust clouds by requiring that the energy emitted by a grain be equal to that it absorbs from the star. The resulting distance from AK Sco is then 25–50 solar radii for the hot dust, and about 10 AU – the orbital radius of Saturn – for the cool component. Thus, the hot dust cloud has essentially the same size as the binary orbit and presumably consists of material left over from its formation, while the cool dust cloud has the size of a typical planetary system (assuming that the one in which we live is typical!).

The CORAVEL data contain one striking piece of information supporting this picture: The luminosity ratio between the two components, as measured by the equivalent widths of their cross-correlation dips, changes up or down by up to a factor two from one orbital cycle to the next (Fig. 3). Again, star spots are unlikely to cause such large variations; even if they did, they should significantly distort the profiles, which is not seen. Moreover, the variations are largest when the stars are farthest apart.

The simplest interpretation appears to be that we are seeing the effect of inhomogeneities in the hot dust cloud not only *in front of*, but probably also *between* the stars. This opens an exciting possibility for mapping out the dust clouds near the system, in the following way: At any given time, we know the precise position of both stars in their orbit. Photometry tells us the *total* obscuration in front of the two stars, and a simultaneous CORAVEL or other spectroscopic observation can give us the *ratio* of the light losses for each component. We can therefore compute, point by point, the amount of dust in front of each star as it goes through an orbital cycle, and draw a map of the dust clouds and eventually of their motions. Perhaps one could even measure the velocities of circumstellar lines at high resolution?

Thus, AK Sco no doubt has lots more fun in store for the observers: There are eclipses to look for and dust clouds to map. Spectroscopically, one can investigate the Li and other element abundances, indicators of chromospheric activity, and signatures of possible magnetic fields: AK Sco is within reach of the CES. And perhaps, one day, it will be possible to resolve the system interferometrically (with the VLT?), although the angular separation is only of the order of 1 mas; its absolute masses and distance could then be determined even if eclipses should not occur.

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Supershells and Galactic Fountains

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In the gaseous disk of our Galaxy as well as in other galaxies, H I structures (shells, bubbles, holes, etc.) on scales of 0.1–1 kpc are recognized to be common features; see e.g. the comprehensive review by Tenorio-Tagle and Bodenheimer (1988). The larger ones are usually named with the prefix "super". The estimated energies which are required to produce such large objects are high – up to some 10^{54} erg. These energetic events must exert a significant influence upon the gaseous galactic disk and corona.

In our Galaxy, the disk and the corona are believed to be evolutionarily coupled in a recycling process, although there is no common opinion about details of the

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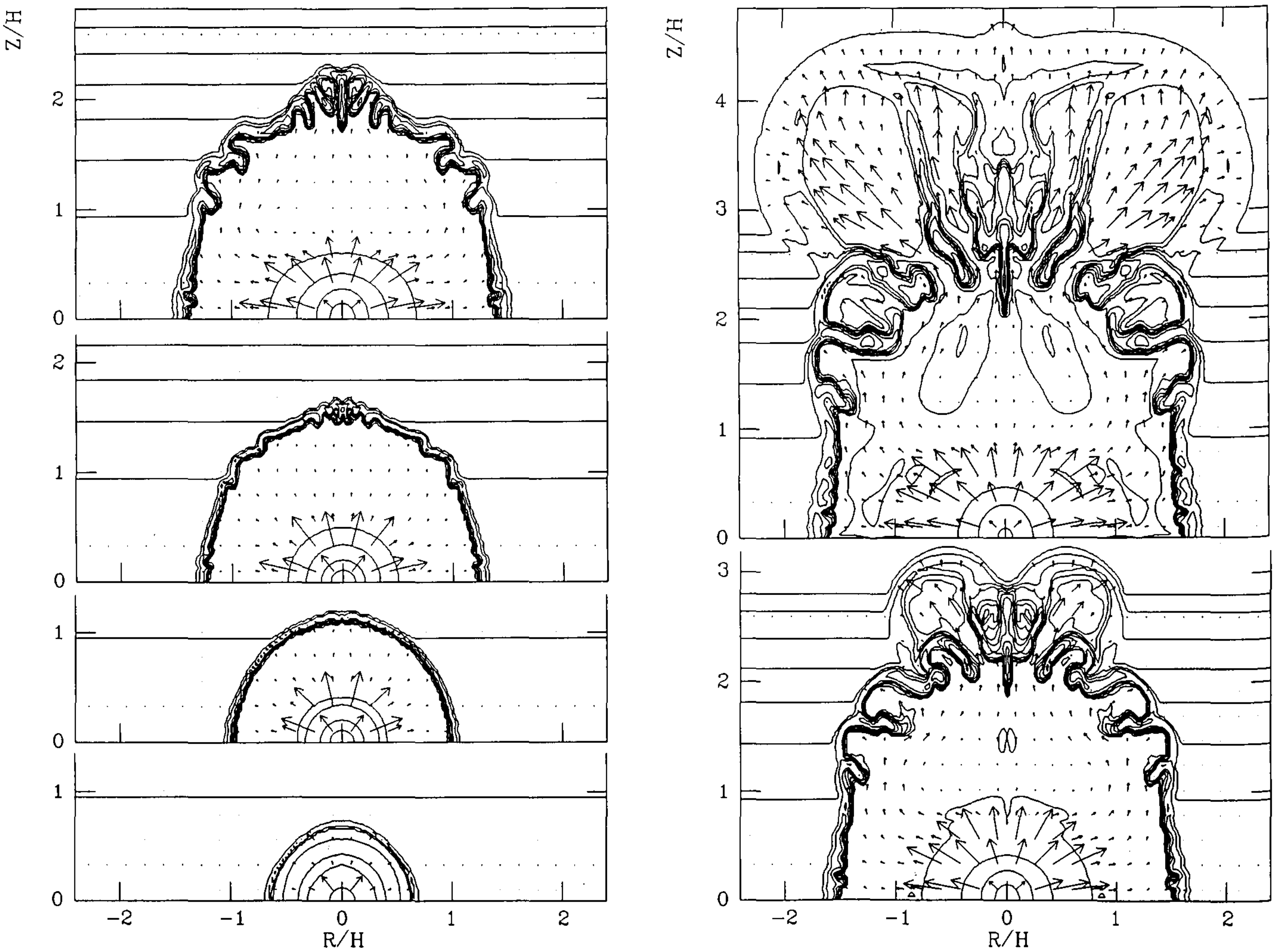

Figure 1: *Evolution of a supershell ($\dot{E}$ = 2 × 10^{39} erg s^{-1}) in a gaussian galactic disk, with n_0 = 1 cm^{-3}, H = 140 pc. Density contours are shown with logarithmic spacing of 0.5 dex at times 0.2, 0.8, 1.5, 2.1, 2.5, 3.0 Myrs. The maximum velocity is 2,200 km s^{-1}.*

process. An evaluation of the density *n* and temperature *T* in the corona and elucidation of the distributions *n(z)* and *T(z)* in the disk remains a challenging subject for observers and theoreticians. It would appear that it is possible to arrive at a better understanding of the topic by interpreting the high energy processes in the disk and corona in a consistent way. The construction of theoretical models of large scale HI structures in galaxies may be considered as a step in this direction.

Several mechanisms have been proposed to explain large scale HI structures in galaxies. The hypothesis of supernova explosions appears to be most consistent with the idea of heating and supporting of the corona by galactic sources (Cox and Smith 1974). However, a single supernova event seems to be unable to break out of the HI disk unless the explosion is presumed to take place substantially off the plane. This means that single explosions can hardly be considered as a source of hot gas for replenishing the corona. Multiple supernova outbursts are more probable, since OB stars are well known to be born in groups, which in the solar vicinity on the average contain some tens of these stars (Ambarzumian 1947, Blaauw 1964).

In order to investigate the evolution of (super)shells which originate as a product of interaction of supernovae with interstellar matter, we have calculated 2D hydrodynamical numerical models. Some important values that are not well known from observations, like energy input rate $\dot{E}$, parameters of gas distribution in z-direction, etc., were considered as model parameters. A typical value of $\dot{E}$ for an OB association in the Galaxy seems to be of the order of 10^{38} erg s^{-1}. According to the models, a break-out from the gaseous galactic disk occurs in the course of the evolution of an OB association in the plane of the disk with gaussian density distribution and density scale height H = 140 pc for $\dot{E}$ = 2 × 10^{38} erg s^{-1} in ~7 × 10^6 years. For the more energetic case ($\dot{E}$ = 2 × 10^{39} erg s^{-1}) this event occurs after ~2.5 × 10^6 years. In Figure 1, the evolution of the latter model is illustrated.

The first phase of this evolution is rather well understood in terms of the theory of interstellar bubbles driven by stellar wind (Weaver et al. 1977). Supernova explosions are interpreted in our models as a continuous and powerful stellar wind. The freely expanding wind soon stops and the velocity of expansion decreases from ~2,000 km s^{-1} to ~100 km s^{-1}. The stopped wind then acts as a giant, hot isobaric gaseous piston driving a massive cool shell. A dense, relatively cool HI shell contains swept interstellar gas. This gas is shocked (the shell velocity is much greater than the sound speed in an ambient interstellar medium) and heated up to ~10^7 K. Then it cools down to T ≈ 10^4 K or less, due to radiative losses of internal energy. The top of the shell becomes unstable (Rayleigh-Taylor instability) when it reaches ~1.5 H and then breaks into fragments. The fragments can be as massive as ~10^3–10^4 solar masses and move with ~100 km s^{-1}. For the less energetic case (typical for the Galaxy), the masses and velocities of these fragments are 2-3 times lower. The number of fragments is of the order of ten, and the total mass never exceeds 0.1 times the mass of the shell. Calculations with an exponential atmosphere reveal a smaller tendency to fragmentate. As said above, however, it is not yet possible to make an appropriate choice of the galactic atmosphere. Moreover, the structure of the disk in the z direction appears to be dependent on blow-out events and the following dynamical evolution of the expelled gas. Corbelli and Salpeter (1988) have for instance shown that relatively weak current blow-out activity can be effective in compressing an outer H I disk and, possibly, in giving it a sharp edge.

The evolution of the expelled gas may be described in terms of a "galactic fountain" model, as proposed by Shapiro and Field (1976). Due to thermal instability, the rising hot gas converts into H I clouds falling onto the disk. These clouds resemble some of the so-called "high velocity" clouds (HVC) discovered by Dutch astronomers in the middle of the 60's; see the recent survey paper of Hulbosh and Wakker (1988). Such models of the galactic HVC – the first one was elaborated by Bregman (1980) – seem to be attractive. The main problem of the models is poor knowledge of n and T in the galactic corona and consequently a badly known cooling time scale. For typical $T = 2 \times 10^6$ K and $n = 2 \times 10^{-3}$ cm^{-3}, say, the (radiative) cooling time exceeds 10^8 years, which appears to be longer than the time scale of heating by supernovae.

Without discussing in detail the results obtained in our model calculations (see Igumentshchev et al. 1988, 1989; very recent results are in preparation for publication), we note that cool fragments may be interpreted as seed clouds for HVC. The masses of observed HVC, when estimated under the assumption that they are situated at mean galactic distances, are 10^4–10^7 solar masses. The fragments seem to be smaller, but it is possible for them to grow. They are massive and large enough (R $\sim$20–50 pc) to persist against evaporation. Moreover, if rising with the given velocities up to 0.7–2 kpc over the plane, they could act as a sink of thermal energy of hot coronal gas. A simple estimate, according to the theory of McKee and Cowie (1977), shows that the largest fragments are resistant to evaporation (radii exceeding the critical value) and should condense.

Note also that the proposed mechanism of sequential supernova explosions cannot explain the extremely large ($R \simeq$ 1 kpc) supershells unless one assumes very low densities $n \simeq 0.01$ cm^{-3}. Even in that case one must suppose enormously rich OB associations in order to explain the large kinetic energies. On the other hand, the most common supershells with radii $\sim$0.2–0.5 pc are explained quite well by this model.

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Searching for Light Echoes from Circumstellar Dust Shells Around SN 1987A

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The Space Telescope Science Institute coronograph (described in the *Messenger,* **47,** p. 43) mounted on the 2.2-m telescope at La Silla was used by myself and my colleague Chris Burrows to look for light echos in the immediate vicinity of the SN 1987A in the LMC. This technique allows us to probe circumstellar regions from about 2 to 20 arcseconds in the vicinity of very bright objects such as the SN 1987A for faint features otherwise completely lost in their glare. At the time of the observation reported here, carried out on December 21, 1987, the SN brightness was V = 6.2. Echoes at these angular distances and time of observation correspond to linear distances from the SN roughly in the range of 1–15 parsecs in front of the star near the observer's line of sight. At these distances, any echo would most probably be emitted from matter expelled from the SN itself at some earlier epoch when it was a hot main-sequence giant and/or a red giant star in its way towards eventually becoming a SN. Theory predicts and many observations confirm that shells of swept-up stellar material including dust formed in the outer layers of an expanding photosphere or wind would be expected to linger in the general vicinity of the SN and be observable by the delayed scattering of the SN light pulse. The echo would manifest itself in the form of a luminous ring of several arcseconds radius centred roughly on the SN itself. The ring might, in practice, be incomplete if the shell structure were not homogeneous. Rings of this type located much further away have been observed around SN 1987A (see the *Messenger,* No. 52, p. 13) but are thought to be due to scattering from sheets of interstellar dust lying between us and the SN and not related to the SN itself.

The accompanying composite image corresponding to a 10-minute exposure taken with the ST ScI coronograph through a standard B filter illustrates graphically the result we obtained. The full field of view shown in this image is 22 by 36 arcseconds with North up and East to the left. The occulted centre of the SN is located at the position of the cross at the centre of the image where the occulting wedge running EW is 1.9 arcseconds thick. Each pixel in the 512×320 pixel frame corresponds to an area of $5 \cdot 10^{-3}$ arcseconds^2 while 1″ corresponds to a linear scale of $\sim$0.83 light-years at the source. The left or