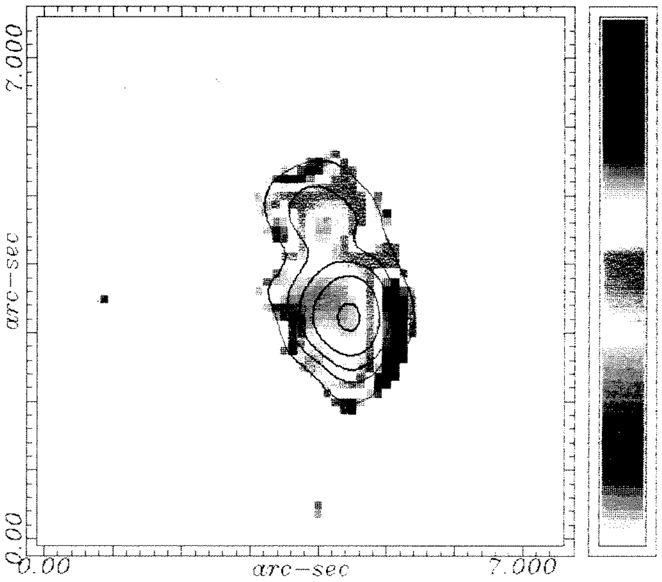

Figure 19.

"starburst"—probablement à travers un mécanisme de photo-thermo-dissociation ou de deshydrogénation—et un mécanisme, encore plus efficace, relié à des chocs dans des supervents ou des restes de supernovae individuels; ii) il met en évidence que les PAHs ne peuvent survivre que dans les régions denses des halos de nuages moléculaires, là où ils sont suffisamment écrantés.

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Doppler Imaging of Stars

While many people have been working to produce better direct images of extended objects through control of the dome environment to improve seeing and through using active optics, a few of us have been working toward getting good indirect images of the surface features on stars. The idea behind getting surface images of these stars is simple but the actual task is fairly laborious. Imagine a small region of a star's surface with an enhanced contribution to the integrated rotationally broadened line profile. As the small region comes into view at the limb of the star as a result of stellar rotation, we will see a "bulge" in the observed line profile of the star on the blue side of the line profile. While in view, as rotation carries the region across the face of the star, we will see the bulge move systematically through the profile. The general sense of the motion will be from blue to red until the bulge disappears, but latitude plays a role in the behavior of the bulge's motion. For example, a bulge due to a spot located near the pole, in a star with an inclination such that the spot is always visible, will always be present in the observed line profile, moving from the red wing to the blue for half the time and from the blue wing to the red. Such variations in behavior with latitude permit us to map the surface in both latitude and longitude. Computer programs have been written over the last few years to solve the inverse problem of deriving a surface map of a star from high resolution, low S/N spectra of the star taken at many phases of its rotation.

We are concerned with two types of features on stellar surfaces. The Ap stars display a non-uniform distribution of element abundances over their surfaces, a pattern of distribution that presumably finds it origins in the structure of the large magnetic fields common to these stars. Cooler stars, of mass closer to the mass of the Sun, exhibit cool photospheric spots similar to sunspots but in the cases of the most active stars these cover a much larger fraction of the stellar surface than do spots on the Sun. The Ap stars are limited in their occurrence to an evolutionary stage near the main-sequence but for the cooler stars we find stars of interest that range from pre-main-sequence objects such as the T Tauri stars, through young main-sequence to post-main-sequence objects such as the RS CVn stars.

Recent work on the Ap star 17 Com has produced maps of the surface abundance for iron, chromium and two rare earth elements plus barium. 17 Com had not seemed like an ideal candidate for Doppler Imaging because it had a Vsin(i) of only a little over 20 km/s. This is rather low compared with other stars chosen for Doppler Imaging. The low Vsin(i) implies a poor surface resolution, especially if stronger lines with wider local line profiles are used for the mapping. By using the narrower weaker lines and taking advantage of the many lines that were

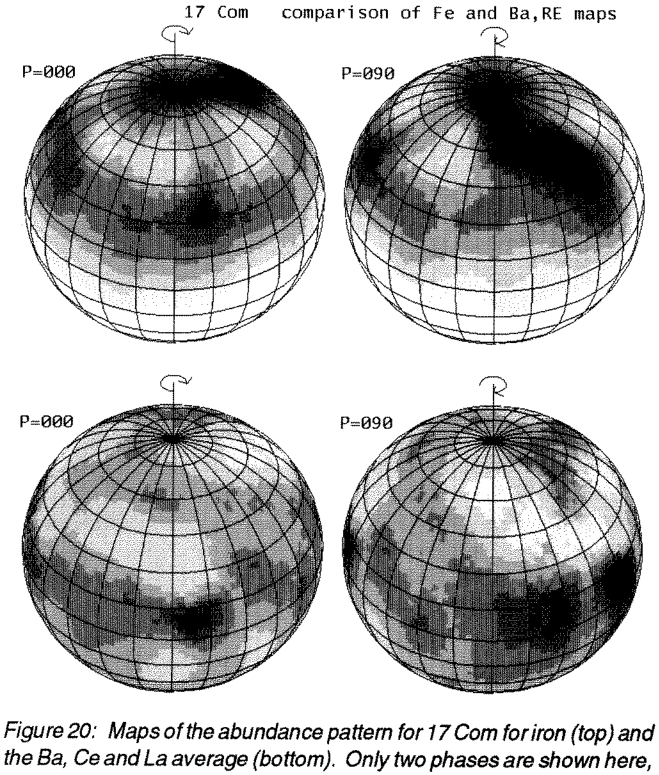

Figure 20: Maps of the abundance pattern for 17 Com for iron (top) and the Ba, Ce and La average (bottom). Only two phases are shown here, phase 0 and phase 90 degrees based on the ephemeris JD(mag minimum)=2439197.0+5.0808E. The range of abundance represented is Fe, -4.5 to -2.5 in steps of 0.3 and for the Ba, rare earth average (here only the range has physical significance) the range is -8.5 to -6.0 in steps of 0.5.

free of blends and thus suitable for imaging, it was possible to make something of a virtue of the lower Vsin(i). Ample images were obtained and intercomparison of the many maps for the same or similarly behaved atomic elements allowed the identification and elimination of those maps which were affected by problems such as undiscovered blends or external error due to reduction problems. Co-adding many maps beat down the noise levels so that reliable maps of distributions of iron, chromium and the rare earth, barium group could be produced. In earlier work we had seen ring structures symmetric about the magnetic axis of the Ap star epsilon UMa. 17 Com (see figure 20) seems to have a more crude loop of enhanced abundance in both the Fe and Cr map and a matching pattern of depleted abundance for the Ba and rare earth elements. Indeed, the most striking aspect of the maps is the extent of the match between the pattern for the iron peak elements and the pattern of depletion for the Ba and rare earth map. The maps for the Fe and Cr patterns are extremely similar. The loop feature is ragged and stretched in longitude. It appears that it may be symmetric about a point roughly half way between the equator and rotational pole at longitude near zero. From the work of Preston, Stepien and Wolff (*ApJ*, **156**,653,1969) on the magnetic variability we can obtain an estimate of the location of the negative magnetic pole. It appears that this coincides with the loop "centre"; however, the magnetic measurements are scattered and the phasing between the maps shown here and the magnetic observations is uncertain by about 50 degrees of longitude because of the more than twenty years lapsed between the magnetic and the mapping observations. The radius of the loop of Fe and Cr enhancement and of rare earth depletion is roughly 30 degrees in the latitude direction but stretched to more like 120 degrees in longitude. Maps of epsilon UMa and theta Aur show clear circular features centered on magnetic poles whose positions are reasonably well known. Although the maps of 17 Com are not as satisfactory, they are consistent with that pattern. As was found for epsilon UMa and theta Aur, regions of enhanced or depleted abundance are not smoothly defined, but show gaps and other irregularities. It seems that we must either look for a mechanism to explain a rather variable element diffusion in the presence of an ideal highly symmetric magnetic field or we must assume that the field may be less than perfectly symmetric.

A mapping project on the young main-sequence star LQ Hya (*A&A*, **268**,671,1993) has revealed large regions with average surface temperatures only a few hundred degrees below the photospheric temperature (see figure 23, back cover). Observations by others of TiO suggest that there are very cool spots on the surface of this star so we conclude that the large, moderately cool, regions seen in our map likely represent spot groups covering substantial regions of the stellar surface. Since the publication of our map we have had the opportunity to see work by Piskunov and Saar that shows some remarkably similar features to those found by us. This suggests that we will be able to trace the temporal behavior of these features with further mapping. Of particular interest will be the lifetimes and relative movements of the spots. Another point of particular note in the images of LQ Hya is that, in contrast to the images obtained for evolved objects such as the RS CVn star EI Eri, there is no huge polar spot feature.

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Régions de photodissociation à 3.3µm: M42 et M17.

La caméra CIRCUS a été utilisée pour obtenir des images à 3.3µm, bande des poussières (ou grandes molécules) et continuum, de régions de photodissociation au sein des complexes de formation stellaire. Ces régions correspondent à l'interface entre une région d'hydrogène ionisé créée par un groupe d'étoiles massives et le nuage moléculaire qui a donné naissance à ces étoiles. Là, un champ de rayonnement intense (environ 0.1 W/m^2) et riche en photons UV met à jour un milieu dense (10^5 cm^{-3}), dissociant les molécules et évaporant les manteaux formés sur les grains de poussière. Dans l'hypothèse où l'émission à 3.3µm est due à de grandes molécules comme les PAHs, il est possible qu'une grande quantité de PAHs soit ainsi libérée dans ces régions, après leur formation par accrétion de carbone sur les grains de poussière dans les phases denses et froides des nuages interstellaires. C'est à la fois pour tester ce genre d'hypothèse et trouver de nouvelles contraintes observationnelles concernant la nature physico-chimique des particules interstellaires étant à l'origine des bandes d'émission infrarouges, mais aussi pour étudier la structure à petite échelle du gaz moléculaire dans ces régions d'intéraction, que ces observations à 3.3µm ont été réalisées.

Les Figures 21 et 22 montrent les images obtenues pour deux champs sélectionnés dans les complexes associés respectivement aux nébuleuses M17 (interface sud-ouest) et M42 ("barre d'Orion"): (a) filtre 3.3µm étroit, (b) continuum sous-jacent obtenu par combinaison des mesures en filtre étroit et filtre large, en utilisant le profil de raie à 3.3µm mesuré par Sellgren et al. 1990 (*ApJ*, **349**, 120). Noter que ce continuum exclut une éventuelle contribution des raies associées situées

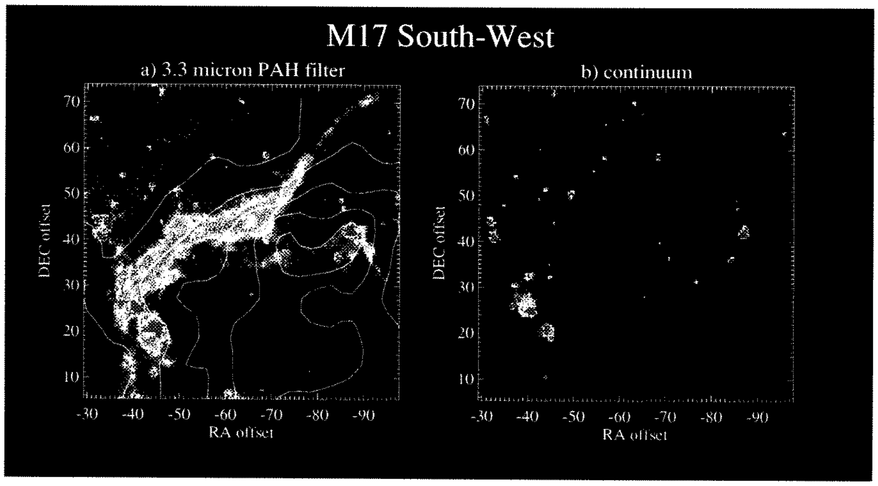

Figure 21: Interface région HII/nuage moléculaire dans M17 sud-ouest, observé à 3.3µm avec la caméra CIRCUS. (a) filtre 3.3µm "étroit" (0.16µm), (b) continuum sous-jacent. Les contours sont ceux de l'émission intégrée dans la raie $C^{18}O$ 2-1 et montrent l'emplacement du nuage moléculaire (Stutzki and Güsten 1990, ApJ, ***356****, 513), la région HII se trouve dans le nord-est de l'image. Offsets en secondes d'arc par rapport à l'étoile SAO 163157, $\alpha = 18^h17^m34^s5$, $\delta = -16^\circ\ 13'24''$, 1950.*