Astronomy

Galactic irregularities — nature or nurture

from Simon D.M. White

FOR many years after Hubble demonstrated the validity of Kant's view that galaxies are separate 'island universes', astronomers tended to treat galaxies as independent closed systems well removed from external influences. Their form was assumed to reflect the conditions in which they were born and the manner in which they had aged. Recent research, however, has placed ever greater emphasis on environmental effects and on interactions between galaxies and their neighbours. Such interactions seem likely to have left their imprint on many aspects of galaxy structure and offer a possible explanation for a number of irregularities often seen in the outer regions of spiral galaxies. Nevertheless, a recent paper by Krumm and Shane (*Astronomy and Astrophysics* **116**, 237; 1982) shows that the case for an external rather than an intrinsic source for these irregularities is still far from proven.

The authors made maps of the distribution of interstellar hydrogen gas in two of the most isolated and asocial spiral galaxies known; they found the galaxies to have marked asymmetries similar to those which in other systems have been ascribed to the influence of nearby companions. This evidence suggests that both 'nature' and 'nurture' need to be taken into account to explain the origin of the features.

The idea that environment could have a determining effect on galaxy structure stemmed from a number of observations. The global morphology of galaxies is clearly related to the proximity of neighbours. In regions of space where the density of galaxies is high, elliptical galaxies are common, spiral galaxies are rare and galaxies tend to have little interstellar gas. In lower-density regions, spirals form the dominant population and ellipticals are much rarer; most galaxies have a significant interstellar medium. This strong trend shows either that galaxies 'knew' what their current environment would be at the time they were formed, or that their current morphology is a result of environmental influences.

Such influences are directly observable in certain galaxy pairs that are just now in the process of colliding and that show strong distortions characteristic of tidal interaction. The time during which these distortions are readily apparent is quite short, so many apparently quiescent systems may have been subjected to violent distortions in the past. Permanent structural changes must have been induced by such distortions. The value of studying extremely isolated galaxies, such as those selected by Krumm and Shane, is that they provide a control group for which past strong encounters seem very unlikely; there are just no candidate perturbers.

Several kinds of structural change may be induced in a spiral galaxy by encounters with other systems. The gravitational field of the intruder may rip off weakly bound material in the outer regions and thus tidally truncate the galaxy's mass distribution. At the same time the distortion of the remaining material may produce long-lived warps near the edge of the galaxy and may trigger the conversion of a significant amount of gas into stars. Recent studies have suggested that elliptical galaxies may indeed be tidally truncated in regions of high galaxy density, that warps and global spiral patterns in spiral galaxies can be related to the presence of companions and that galaxies in close pairs have higher rates of star formation than similar isolated systems.

These trends are at best only rather weak, however, and striking exceptions can be found. Despite their isolation the two galaxies of Krumm and Shane are no more extended and contain little more gas than typical spirals. Moreover, one of them shows a pronounced warping of its hydrogen disc, and the hydrogen distribution of the other is both locally clumpy and globally asymmetric. In these two cases, at least the asymmetries must be intrinsic and must reflect either internal instabilities or a very slow rate of settling to a symmetric state.

Neither possibility fits well the standard models for the structure of galaxies, and at an IAU symposium in Besançon last summer A. Toomre concluded that there is at present no convincing theoretical explanation for the existence of warped discs in spirals which do not have companions. His tentative best bet was that the observed galaxy is surrounded by a massive but invisible halo which is flattened along an axis inclined to that of the central disc. In the outer regions, the disc then bends towards the principal plane of the halo. This model amounts to replacing the asymmetric gravitational field of an observed companion by the asymmetric field of an unseen halo when no such companion is in evidence. It accounts quite prettily for the observations, but there is so far no other evidence for such a misaligned dark halo. □

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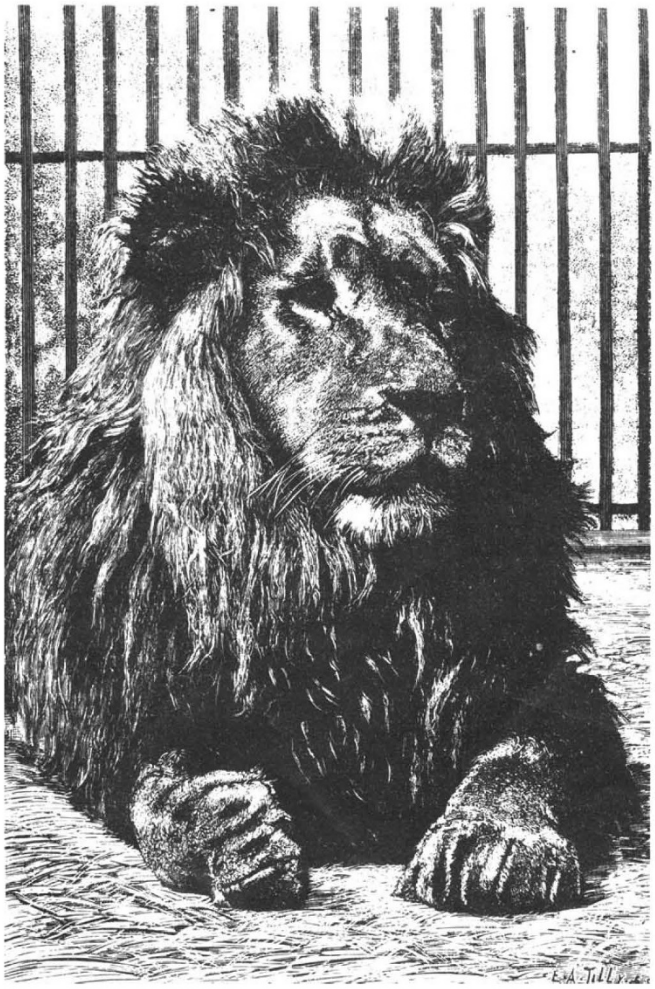

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THE LION AT REST

THIS illustration from *La Nature* is after a photograph of one of the lions in the Zoological Gardens, London. This photograph may be regarded as one of the numerous triumphs of instantaneous photography, valuable both to art and science. The original was rephotographed in Paris directly on wood, by means of a special collodion, at present much used. This has assured a perfectly faithful reproduction of the original, exhibiting all the characteristic details of the lion at rest. From *Nature* **27**, 584, 19 April 1883.

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