THE INITIAL MASS FUNCTION

Richard B. Larson
Yale Astronomy Department
Box 6666
New Haven, CT 06511, USA

As we have already heard, estimates of the fraction of a star-forming cloud that is converted into stars and of the overall star formation rate in galaxies depend crucially on the assumed stellar initial mass function, which must be known before any quantitative conclusions can be drawn about galactic evolution. Instead of attempting to summarize current knowledge on the subject, it may be more useful at this point to emphasize the large uncertainties that still remain. The importance of these uncertainties was made clear in the excellent talk by Walterbos on star formation in M31: in order to derive the total star formation rate from various data indicating the number of massive stars present, Walterbos adopted a "middle-of-the-road" IMF previously used by Kennicutt, but pointed out that if the steeper IMF proposed by Miller and Scalo in 1979 were used instead, the inferred SFR would have to be multiplied by 3.4, whereas if a flatter IMF with $x = 1$ (cf. Van Buren, *Astrophys. J.* **294**, 567, 1985) were adopted, the SFR would be multiplied by 0.25. Thus the compromise IMF adopted by Walterbos could yield an SFR that is incorrect by a factor of four, and we are not even sure whether it is more likely to be too high or too low. It should nevertheless be noted that Van Buren's more recent work used a larger sample of stars than previous studies and applied more careful corrections for extinction, and the result was a flatter IMF, i.e. a larger proportion of massive stars. This suggests that the widely used Miller-Scalo IMF may be too steep for the most massive stars, and that many estimated SFRs based on it should be revised downward.

In addition to the uncertain slope of the upper IMF, two further unresolved questions that may have even more far-reaching implications are whether the IMF continues to increase monotonically with decreasing mass down to masses well below one solar mass, and the related question of whether the IMF is universal or varies with time and location in galaxies. If it is universal, then a function not greatly different from Salpeter's original power law may still be an acceptable approximation, while if it varies, there are many other possibilities, including the possibility that the IMF is bimodal and consists of separate high-mass and low-mass parts that have different dependences on space and time.

Unfortunately, even such a basic issue as the universality of the IMF cannot yet be definitely resolved, given the present data. Nearly all of the evidence is affected by large uncertainties and difficulties of interpretation, and my own efforts to understand the subject have provided, more than anything else, a lesson in the uncertainties of astronomical data. On the one hand, for example, a respectable collection of data and arguments can be assembled to support a case that the IMF is universal, or at least that

R. E. Pudritz and M. Fich (eds.), Galactic and Extragalactic Star Formation, 635–636.

this is a good working hypothesis for most applications. Most workers subscribe to this viewpoint, either because it is the simplest one to work with or because they do not regard it as proven that the IMF varies. On the other hand, a fairly impressive body of (mostly indirect) evidence can be assembled to support a case that the IMF varies, possibly depending systematically on local conditions. This evidence was reviewed extensively by Scalo in 1986. Since then, more evidence has been found by McClure and collaborators that the IMF in globular clusters is variable. Theoretically, it would be surprising if the IMF did not vary with local conditions, although we are still a long way from being able to make definite theoretical predictions about the IMF.

While all of the items of evidence suggesting variability of the IMF are individually subject to considerable uncertainty, especially when their interpretation requires many assumptions, it is perhaps significant that in nearly every case where a departure from a standard Salpeter-like IMF has been claimed, it is in the sense that a relative excess of massive stars or a truncation of the lower IMF compared with a Salpeter IMF is indicated. The case for an increased proportion of massive stars seems strongest for regions or systems with high rates of star formation, especially starburst systems. Most of the arguments for a non-standard IMF place strong weight on discrepancies by factors of two or three that are probably not individually believable, given the present state of the art (recall the factor-of-four uncertainty in the SFR associated with the form of the upper IMF). Nevertheless, the fact that several different types of evidence all suggest an excess of massive stars in regions of active star formation leads me to suspect that the IMF does, in fact, vary in this sense, even though we may still be a long way from being able to prove this conclusively.

Given this state of affairs, it would seem that we have no choice but to recognize that the IMF in galaxies is, like the distance scale, still quite uncertain, and is likely to remain so for some time to come. In the case of the extragalactic distance scale, workers in the field have had to admit that they do not know the Hubble constant and cannot agree on a standard value, and therefore they explicitly indicate the uncertainty in the distance scale by the parameter h that appears ubiquitously. Perhaps researchers who wish to interpret data on star formation by assuming an IMF can do no better than to make equally explicit the uncertainty unavoidably associated with the choice of an IMF.