1. Introduction

The recognition that some galaxies contain central rectangular bars dates back at least as far as Curtis’ (1918) classification of a number of such systems as “φ-type spirals.” This fundamental property of disk galaxies was codified in the form we know today in Hubble’s (1926) classic “tuning fork” diagram, where barred and unbarred spirals form the prongs of the fork. Over the succeeding century, observations have improved, and in particular most recently infrared data have allowed us to view the stellar components of galaxies almost free from the confusing effects of dust obscuration. This mass of data has shown that bars are very common features, found in over a half of all spiral galaxies (Whyte et al. 2002).

It should therefore come as no particular surprise to find that the Milky Way is also a barred system. However, the commonness of such galaxies also raises the question of why one should care whether the Milky Way is barred or not. There are, after all, plenty of other galaxies that are oriented much more favorably than the Milky Way: not only is our own galaxy edge-on, rendering any bar almost invisible, but different parts of the Milky Way are different distances away, greatly complicating the geometry. Why not learn all there is to know about bars by studying the plethora of more accessible external systems? In fact, there are several good reasons why we might want to know about the Milky Way’s bar. First, it is natural to be inquisitive about our own neighborhood, and want to know what our galaxy would look like to an outsider (see Figure 1). Second, we have a mass of detailed information about the Milky
Figure 1. Images of two nearby Sbc galaxies, the unbarred M100 and the barred M109. Which would the Milky Way resemble to an intergalactic tourist? (Images from D. Malin and NOAO.)

Way that we have only been able to obtain because of its proximity. In order to put these data about small-scale structure, star streams, stellar populations, star formation, etc, into the broader context of galaxy evolution, we need to quantify the global properties of the galaxy in which they were found. Finally, and perhaps most importantly, although our position within the Galaxy complicates the understanding of its structure, it also provides us with information on the three-dimensional properties of its bar that is not available in any other system. Since we know very little about the three-dimensional shapes of bars, the Milky Way offers a unique laboratory for studying the structure of these systems.

In fact, our lack of understanding of their three-dimensional structure even leads to some ambiguity as to what exactly is meant by the term “bar.” In particular, it is not clear whether one should draw a distinction between a spheroidal (possibly triaxial) central bulge and a bar component. The different nomenclature may just reflect the limitations of our two-dimensional views of these systems: a triaxial structure that would be identified as a bar in a face-on system would be classified as a bulge component if the same system were viewed edge on. Indeed, there is now strong indirect evidence that bulges and bars are at the very least intimately related (Bureau & Freeman 1999, Merrifield & Kuijken 1999). In order not to prejudge the issue, this review will not draw any absolute distinction between the various putative components of the Galaxy in its central few kiloparsecs, but rather will look at the total distribution of stars and gas to see how far they are from axisymmetry, and hence how strongly the Milky Way is barred in that global sense.

In addition to referring the interested reader to the sophisticated treatment of the wealth of data available for such studies, we will attempt to develop some simple models that illustrate the particular challenges of investigating the bar in our own galaxy and the unique possibilities that its geometry admits.
The Galactic Bar

Section 2 looks at the properties of the bar that can be derived from the Milky Way’s gaseous components, while Section 3 explores the stellar distribution. In Section 4, we place the Milky Way in the context of other barred galaxies, and in Section 5 we take a brief look at what the future may hold for studies of the Galactic bar.

2. The Bar in Gas

Although most people think about distortions in starlight when considering bars, the earliest evidence that the Milky Way is barred came from its gaseous component. This is not surprising, as the Milky Way is much like an external system viewed edge-on, and in such cases a bar is almost impossible to detect photometrically. The best clues to the existence of a bar in an edge-on system come from the kinematics of its gaseous components, where the non-axisymmetric bar potential induces non-circular orbits in the gas.

In the case of the Milky Way, as Figure 2 shows, a plot of line-of-sight velocity versus Galactic longitude (an “l-v diagram”) for the HI gas in the plane of the Galaxy reveals clear signatures of a non-axisymmetric distribution. There is a significant asymmetry between the gas properties at positive and negative longitudes, which is inconsistent with an axisymmetric disk. Further evidence for non-circular motions comes from the non-zero line-of-sight velocities of some...
of the HI gas at zero longitude: if the gas were following circular orbits, then all
of its motion should be transverse to the line of sight at this point.

The strongest feature that illustrates these properties is classically known
as the “3 kpc expanding arm,” because of its approximate radial location in the
Galaxy. This feature, highlighted in Figure 2, is asymmetric about the center
of the Galaxy, lying between Galactic longitudes of \( l^- \sim -20^\circ \) and \( l^+ \sim +35^\circ \).

Tracing it through the center of the Galaxy reveals that it crosses zero longitude
at a velocity of \( v_{\text{los}}^0 = -53 \text{ km s}^{-1} \); presumably this loop in the \( l-v \) diagram re
crosses \( l = 0 \) at positive velocity, but this part of the feature is too faint to trace
reliably. This non-zero line-of-sight velocity is inconsistent with an axisymmetric
picture of the Galaxy with gas on circular orbits, as all gas motion in this
direction should be transverse to the line of sight. It was this observation that
led to the idea that the feature might be an expanding arm of material flung out
from the center of the Galaxy in our direction. As we will see below, however, it
is now understood as arising from the non-circular motions that occur in bars.

The interpretation of this feature as a bar is usually attributed to de Vau-
couleurs (1964), who first made such a connection. However, his description
of “focalized vortices plunging toward the nucleus” is not one that would be
recognized today. It is therefore perhaps unsurprising that the properties he
inferred for the bar turn out to be erroneous: even the side of the bar that lies
closest to us was incorrectly identified. The earliest accurate modeling of this
feature seems to have been undertaken by Shane (1971)\(^1\), who pointed out that
this feature could be explained by an elliptical ring of gas with its major axis
oriented at an angle of \( \phi \sim 20^\circ \) to the line of sight, and a short-to-long axis ratio
of \( \sim 0.6 \). Subsequent analysis (e.g. Peters 1975) confirmed this result, and even
recent full gas-dynamical simulations (e.g. Fux 1999) all find that a feature of
this kind is required to fit the observed \( l-v \) diagram.

In order to obtain some insight into the reason for the robustness of this
result, it is instructive to see if it can be understood on the basis of a simple
calculation. Specifically, can one go from the three basic observed quantities, \( l^+ \),
\( l^- \) and \( v_{\text{los}}^0 \) to obtain the three parameters of the ellipse, \( b \), \( a \) and \( \phi \)? The values
of the spatial coordinates, \( l^+ \) and \( l^- \), clearly do not provide enough information
to solve for all three ellipse parameters, but obviously provide some constraint:
the fact that they are not equal rules out an axisymmetric feature. One can
therefore narrow down the range of possible ellipses using \( l^+ \) and \( l^- \), and, for
example, solve for the axis ratio \( b/a \) as a function of the feature’s angle \( \phi \) to the
line of sight. This constraint is illustrated in Figure 3.

A further constraint comes from the non-zero velocity observed at zero lon-
gitude. This observation can be interpreted rather crudely in the epicyclic ap-
proximation, in which the elliptical orbit of the gas is constructed from a parent
circular orbit of angular frequency \( \Omega \) and radius \( R_{\text{bar}} \) upon which an elliptical
perturbation of radial amplitude \( X \) and angular frequency \( \kappa \) is superimposed
(Binney & Tremaine 1987). At an arbitrary longitude, the line-of-sight velocity
of gas following such motions is an ugly mixture of components of the circular
motion plus the radial and tangential perturbations. However, at \( l = 0 \) the only

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\(^1\)This paper is seldom noticed because it has the misfortune to be in one of the few volumes
that is missing from the ADS, so is passed over in many literature reviews.
Figure 3. Constraints on in-plane flattening and position angle of the Galactic bar relative to the Sun–Galactic-center line. The dotted line shows the constraint provided by the asymmetry in the extent of the 3 kpc arm between positive and negative Galactic longitudes, while the short-dashed line shows the simple kinematic constraint derived from this feature. The intersection of these lines implies that the 3 kpc gas ring is oriented at an angle of $\phi \sim 25^\circ$, with a short-to-long axis ratio of $b/a \sim 0.5$; since the intersection occurs at close to the maximum of the dotted line, the significant uncertainties in the analysis producing the dashed line should have little impact on the inferred value for $b/a$. The long-dashed line shows the constraint on the photometric bar provided by its asymmetry about the Galactic center; again, the shape of this curve means that the derived value of $b/a \sim 0.6$ for the stellar component is robust against uncertainties in $\phi$. 
line-of-sight component is the radial perturbation, which must produce the observed value of $v_{\text{los}}^0$. Writing the radial coordinate of gas as $R = R_{\text{bar}} + X \cos \kappa t$, we find that $\dot{R} = -X\kappa \sin \kappa t$. The situation is further simplified if it is assumed that the speed of circular orbits in the Milky Way, $v_c$, is approximately constant, as observed in most external spiral galaxies (although such an assumption must break down at small radii where the rotation speed must drop toward zero). For such a flat rotation curve, $\kappa = \sqrt{2}\Omega = \sqrt{2}v_c/R_{\text{bar}}$ (Binney & Tremaine 1987). Putting all this information together, we find that

$$\frac{X}{R_{\text{bar}}} = -\frac{v_{\text{los}}^0}{\sqrt{2}v_c} \times \frac{1}{\sin(\sqrt{2}\phi)},$$

(1)

and hence the ellipse’s axis ratio

$$\frac{b}{a} = \frac{R_{\text{bar}} - X}{R_{\text{bar}} + X} = \frac{1 - X/R_{\text{bar}}}{1 + X/R_{\text{bar}}},$$

(2)

which is just a function of $\phi$. This function is also plotted in Figure 3.

The spatial and the kinematic constraints are both met where the lines intersect. It is therefore apparent that a self-consistent model requires an ellipse of gas with an axis ratio of $b/a \sim 0.55$ at an angle to the line-of-sight of $\phi \sim 25^\circ$. A number of somewhat dubious approximations have gone into this argument—the epicyclic approximation has been pushed well beyond the perturbative regime where it is strictly valid, for example. However, full hydrodynamical modeling of the Galactic $l$–$v$ diagrams in HI and CO come up with essentially identical parameters for this gas ring (Fux 1999). If this feature is interpreted as a signature of the Galactic bar, then we have a measure of its angle to the line-of-sight; as we shall see below, however, the axis ratio requires further interpretation.

3. The Bar in Stars

Seeing the stellar bar in the Milky Way presents particular difficulties. As has already been mentioned, it is viewed from a most unfavorable direction, but in addition it is seen through many magnitudes of optical extinction, and it covers many square degrees on the sky. These latter challenges were finally overcome when the COBE map of the sky was published, and Galactic astronomers began analyzing the parts of the data that the cosmologists discarded (see Figure 4). The COBE satellite’s infrared coverage spanned the optimal point in the spectrum where emission is still dominated by stars yet extinction is minimized, and the all-sky coverage of the survey meant that the large extent of the structure was no longer a problem, so finally some photometric insight into the bar’s properties could be obtained.

In external edge-on galaxies, bars are completely undetectable from photometric data. The only clues to their presence come from indirect indicators such as a plateau in the light distribution at small radii (e.g. de Carvalho & da Costa 1987). However, such features could equally well be axisymmetric disk features, so no firm conclusions can be drawn. One can do rather better if one measures optical spectra along the major axes of such galaxies, as both the stellar kinematics (as determined from absorption-line spectra) and gas kinematics
Figure 4. De-reddened infrared map of the center of the Galaxy as seen by COBE. Approximate ellipse fits to contours away from the Galactic plane, separated by one e-folding in surface brightness, illustrate the asymmetry caused by the Galactic bar. The measured scalelengths are indicated. (Adapted from Fux 1997.)

(as seen in emission-line spectra) show complex structure in the line-of-sight velocity distribution as a function of position (Kuijken & Merrifield 1995), directly analogous to the structure seen in $l$–$v$ diagram of the Milky Way (see Figure 2). It was through such studies that a link was established between the presence of a bar and boxy, or even double-lobed, isophotes in the central bulges of these systems (Bureau & Freeman 1999, Merrifield & Kuijken 1999). Such a link was predicted by numerical simulations, which showed that initially-thin bar structures should buckle perpendicular to their plane, creating triaxial objects with a double-lobed shape when viewed edge-on (e.g. Combes & Sanders 1981). The double-lobed structure apparent in some of the isophotes shown in Figure 4 therefore provides indirect evidence that the Milky Way is barred.

In the case of the Milky Way, however, we can obtain rather more direct evidence for the presence of a bar. Generally speaking, the complex geometry involved in observing a galaxy from the inside greatly hinders the interpretation of the data. On this occasion, though, it actually helps. The finite distance to the bar means that there is a parallax effect: the two ends of the bar are effectively viewed from different directions, causing the projected scale-length of the light distribution to be different on the two sides of the Galactic center. This asymmetry is clearly visible in the map of the light distribution shown in Figure 4.

Perhaps unsurprisingly, there is not enough information in such a two-dimensional map to derive a unique model for the three-dimensional distribution of starlight, even if quite strong symmetries are imposed on the bar [as highlighted by Zhao (2000)]. Nonetheless, a fairly consistent view has emerged as to the basic structural parameters of the bar using the observed asymmetry in the photometry, and once again a simple model provides a useful illustration as to why these parameters are fairly robustly measured.

The simplest plausible model for the bar is a triaxial Gaussian ellipsoid, with principal axes of scalelengths $a$, $b$, and $c$ in the $x$, $y$ and $z$ directions, respectively (where $z$ is the distance perpendicular to the Galactic plane. If viewed edge-on from a large distance at an angle $\phi$ to the $x$-axis, the projected
distribution of light would also be Gaussian with a scale length $c$ perpendicular to the plane and a scale length $A(\phi) = \left[ \frac{\sin^2 \phi}{a^2} + \frac{\cos^2 \phi}{b^2} - \frac{\sin^2 \phi \cos^2 \phi}{\frac{a^2}{\cos^2 \phi} + \frac{b^2}{\sin^2 \phi}} \right]^{1/2}$ (3) in the projected plane. However, since we are not at an infinite distance away, observations at $\pm l$ observe the bar from somewhat different directions, which will yield different projected scalelengths, $A^+ = A(\phi + l)$ and $A^- = A(\phi - l)$. Thus, we essentially have two observables at any given longitude, $A(l) = (A^+ + A^-)/2$ and $f(l) = A^+/A^-; \text{ at } |l| \sim 15^\circ$, for example, we can see from Figure 4 that $A \sim 6.0^\circ$ and $f \sim 1.25$. There are three in-plane physical quantities that we would like to derive -- $a$, $b$, and $\phi$ -- so clearly the problem is under-determined, illustrating the degeneracy in deprojecting from two dimensions to three. However, we can solve for $a$ and $b/a$ as functions of $\phi$, as we did above for the gaseous component; the resulting values for $b/a$ as a function of $\phi$ are also shown in Figure 3.

If we adopt the angle of $\phi \sim 25^\circ$, as derived from the gaseous component, we see that the stellar component must have an axis ratio of $b/a \sim 0.6$. Folding in the value of the vertical scaleheight, $c$, as measured in Figure 4, we find that the bar is a triaxial structure with axis ratios $a : b : c \sim 1 : 0.6 : 0.4$. Again, although this result has been derived on the basis of a simplified model, it reproduces the results of much more sophisticated calculations: Fux’s (1999) matching of N-body simulations to the COBE map and Binney, Gerhard & Spergel’s (1997) direct deprojection of the same data both predict aspect ratios of $a : b : c \sim 1 : 0.6 : 0.4$. This good agreement must occur because the amount of information on the structure of the bar is rather limited in the two-dimensional COBE map, and all the various modeling techniques latch onto essentially the same constraint arising from the asymmetry in the distribution of starlight.

Note that this analysis uses all the light from the central region, and does not attempt to separate out distinct bar and bulge components. The fact that it is possible to produce a coherent picture of the bar region without a separate axisymmetric bulge component adds further weight to the argument that these features should be viewed as different projections of the same physical object rather than as distinct entities. It is also worth noting that this measurement illustrates why it is worth persisting with the challenging task of studying the Milky Way’s bar: such a fundamental measurement of the three-dimensional shape of a bar has not been possible in any other system.

One use that we can immediately make of this unique measurement is to compare the shape of the bar in gas to that in the stellar component. Since the gas disk is essentially confined to the Galactic plane, the stellar bar is clearly rounder perpendicular to the plane than the gaseous bar. It is also apparent from Figure 3 that the stellar component is also rounder in the plane, with an axis ratio of $b/a \sim 0.6$ as compared to the value of $\sim 0.5$ for the gaseous component. This difference in shape can be straightforwardly understood if the stars do not lie on the closed orbits that the gas follows, but instead oscillate about these orbits, adding a more random component to the mean streaming, thus puffing out the structure of the stellar bar.
Figure 5. Plot of Galactic longitude versus velocity for OH/IR stars near the center of the Galaxy, superimposed on the HI data for this region. Those with high outflow velocities have massive progenitors, and hence must be young; in this group, a population coincident with the 3 kpc arm feature in the gas, the signature of the gaseous bar, is highlighted in black. (Adapted from Sevenster 1999.)

It is not yet clear where the stars that currently make up this triaxial bar formed. Some have argued that the stars predate the bar, with little star formation once the bar has formed (e.g. Cole & Weinberg 2002). However, there is also strong evidence for continuing star formation in the bar. As Figure 5 shows, \( l-v \) diagrams for OH/IR stars measured by Sevenster (1999) reveal that those with massive progenitors (which implies they must be young) pick out the same 3 kpc arm feature seen in the gas. Since this feature is a clear signature of material in an elliptical bar-like structure, it is apparent that star formation in the bar is an on-going process.

Such continuing star formation suggests that one should view the puffed-up nature of the stellar bar as arising from a continuing “heating” process, in which the stars are progressively scattered away from the planar gas distribution in which they formed, making their distribution rounder over time. Indeed, the lower mass stars in Figure 5, which are on average older than the more massive stars, show the somewhat larger scatter in velocity that one would expect from a heated population. Another good tracer of intermediate and old populations is provided by planetary nebulae (PNe), which are relatively easy to identify from their emission lines, and whose kinematics can be easily measured from these lines; an analysis of PNe in the region of the Galactic center (Beaulieu et al. 2000) reveals a distribution in the \( l-v \) diagram very similar to the older OH/IR stars in Figure 5, indicating that they have also had extra random motion injected into their velocities.
A simple model for this extra random component involves adding an amplitude $\delta$ in quadrature to the gaseous highly-flattened ellipsoidal distribution, in order to represent the excursions that the heated stars make from the closed gaseous orbits. This heuristic model makes no attempt to explain the details of the scattering process and the resulting complex distribution function of the stars, but such an isotropic swelling of the bar is the simplest manner in which the heating of the stellar component might occur.

Figure 6 shows the effect on the shape of adding progressively larger random components of amplitude $\delta$ to an initial distribution shaped like the Milky Way’s gaseous component with an aspect ratio $a : b : c \sim 1 : 0.5 : 0$. Given the simple-minded nature of this calculation, it is perhaps surprising that one can simultaneously reproduce the values of both $b/a \sim 0.6$ and $c/a \sim 0.4$ with a single value for the amplitude of the random motions, $\delta \sim 0.4a$. This agreement may just be a fortuitous accident, but perhaps it sheds some light on the mechanism by which galactic bars become heated.

4. The Milky Way as a Barred Galaxy

We now look beyond the Milky Way to try and place it in the broader context of spiral galaxies in general. Again, this is partly just to satisfy a natural curiosity about our home galaxy. However, it also has a broader significance if we are
Figure 7. Two-dimensional bar classification, showing the fraction of total galaxy luminosity of the bar plotted versus bar axis ratio for the galaxies in the Ohio State Bright Spiral Galaxy Survey data from the H band. The symbols list the galaxies’ conventional bar classifications of SA (circles) SAB (triangles) and SB (squares). The cross is the comparable measurement for the Milky Way. (Adapted from Whyte et al. 2003.)

to use the results derived for the Milky Way to infer anything about galaxies in general: it is always somewhat risky to draw general inferences from a single object, but it is downright foolhardy to generalize in this way if we already know that the Milky Way is in some way unusual.

The first rigorous attempt to classify the Milky Way as if it were an external galaxy was made by de Vaucouleurs & Pence (1978), who looked at a variety of qualitative and quantitative observations of the Milky Way, and concluded that it should be designated an SABbc(rs) system. One has to suspect, however, that this large string of characters was more a reflection of uncertainty than of a detailed understanding of the Galaxy’s structure. In the case of bar strength, for example, the paper has very little to say on how the classification was made. This reticence is not particularly surprising, as almost nothing was known about the Galactic bar at that time. The SAB classification therefore just reflects the authors’ desire to hedge their bets against future measurements.

Twenty-five years on, we have much more data and information, including the results reviewed in this paper, so we are now in a position to revisit this question of the Milky Way’s classification in comparison to other galaxies. We can also now exploit the greater access to computers and quantitative data in order to move away from subjective classifications by eye to objective measures of quantities such as bar strength. However, even today quantifying bar strength turns out to be a non-trivial issue, since the term “strength” is not well defined: is a very small, highly elliptical feature at the center of a galaxy a stronger or weaker bar than a much larger feature that is closer to axisymmetric? A variety of measures have been deployed, ranging from sim-
ple observational quantities like deprojected isophotal flattenings (Martin 1995) to complex physically-motivated algorithms involving calculating the non-radial gravitational field of the galaxy (Buta & Block 2001).

In the current analysis, we recognize the intrinsically two-dimensional nature of the classification by specifying both an isophotal ratio for the bar as viewed face on, and the fraction of the total galaxy luminosity that lies within this isophote. Figure 7 shows these parameters for the galaxies in the Ohio State Bright Spiral Galaxy Survey as well as the Milky Way. It is apparent from this figure that the conventional SA/SAB/SB classifications of bar strength are primarily driven by the isophote flattening rather than the luminosity of the bar, although there is significant scatter in the quantitative measurements for each of the qualitative classes. Also, somewhat frustratingly for anyone who would like to classify the Milky Way definitively into one of these traditional categories, our galaxy seems to lie in a region of this parameter space where one finds SA, SAB and SB galaxies. It might appear that we have not come very far from de Vaucouleurs and Pence’s tentative SAB classification after all! However, the uncertainty in the classical classification of the Milky Way bar now reflects the limitations of these qualitative schemes rather than any paucity of data on the Milky Way’s bar.

5. The Future

At some level, the Galactic bar is a solved problem. As outlined in this review, there is now a mass of data that provides a coherent picture of the Milky Way as a barred galaxy. There are certainly subtleties that remain to be discovered, but it might reasonably be argued that bars are not subtle things, and we already know the salient properties of the Galactic bar to the accuracy that is likely to be of any interest in studies of galactic structure.

Although there is some truth in this statement, it also reflects our ignorance of the fine-scale properties of bars, which arises from the difficulty of studying these objects in detail at the large distances of external galaxies. There is also a good prospect that important clues to the formation and evolution of bar structures, which are lacking in the broad-brush picture, can be gleaned from this detailed information. The Milky Way therefore offers a unique laboratory for the detailed study of a bar (albeit one viewed from a rather disadvantageous direction).

It is already known that bars can have quite complex structures, with smaller nuclear bars sometimes found within bigger bars at a variety of orientations [as first noted by de Vaucouleurs (1974)]. These nested bars are quite common, arising in around a quarter of all barred galaxies (Laine et al. 2002), so it would not be too surprising to find similar complexity in the arrangement of stars in the Milky Way’s bar. Indeed, preliminary analysis of the 2MASS star counts by Alard (2001) has shown that the asymmetry seen in the COBE data that reveals the presence of a bar (see Section 3) flips in sign within the central couple of degrees, indicative of a secondary bar at a radically different orientation. Our closeness to the Galactic bar means that there is the prospect of probing much closer to the center of the Galaxy than is possible in external barred systems, so we might hope to go down at least two more orders of mag-
nitude in scale to determine whether this bar-within-a-bar is just the beginning of a hierarchy of structures nested like Russian dolls.

Huge data sets like the 2MASS star counts are certainly taking the study of the Milky Way’s structure to a new level. The analysis by Cole & Weinberg (2002) showed that the bar can be detected not only in the asymmetry of the counts, but also more directly by using infrared carbon stars as standard candles to get a crude measure of the third dimension. However, the real revolution will arrive when we unlock the other three dimensions of phase space by measuring the velocities of large samples of stars. There is already some kinematic data available from studies of line-of-sight velocities and proper motions of stars in low-extinction windows toward the Galactic center, and even this limited dynamical information is quite a challenge to reconcile with detailed models of the bar (Häfner et al. 2000), although line-of-sight contamination by non-bar stars may well compromise the analysis. When the next generation astrometric satellite GAIA is launched (ESA 2000), we will have measures of both line-of-sight velocities and proper motions for stars all across the Galaxy, including those in the bar region, as well as obtaining parallax distances to these objects to an accuracy of ∼ 10% which will almost eliminate any problems from line-of-sight contamination. By assigning ages through position on the color–magnitude diagram, one will be able to detect the effects of any secular evolution in the orbit structure [as was done so successfully to measure evolution in the Galactic disk using data from GAIA’s predecessor Hipparcos (Dehnen & Binney 1998)]. These data will push dynamical analysis into a new regime where very sophisticated modeling will be required to study the details of the orbit families that are populated in the bar. The challenges to modeling and interpreting such huge data sets are far from trivial, but they will provide a completely new perspective on the formation and evolution of galactic bars.

The history of astronomy provides a long list of discoveries which have shown that we are nowhere particularly special in the Universe: Copernicus moved us out of the center of the Solar System; Shapley moved the Solar System to a dull suburb of the Milky Way; Hubble proved that the Milky Way is just one of billions of similar stellar metropolises. It should therefore come as no particular surprise to discover that the Milky Way is like the majority of spiral galaxies in that it contains a bar. Although the ordinariness of our situation is in some ways rather a disappointment, it does have one major up side: when in the future we want to learn about generic features of the Universe like bars in disk galaxies, we will not have very far to look.

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