EFFECTS OF CHAOS IN THE GALACTIC HALO

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To study the way in which the principal periodic orbits in a Galactic potential determine orbital structure, horizontal and vertical surfaces of section, i.e. (dR/dt, R) and (dz/dt, z), are being used to explore the potential of Allen & Santillán (1991) and to investigate possible vertical structure in the Galactic halo. The chaotic "scattering" process due to the nearly spherical mass distribution close to the Galactic center in conjunction with the confinement of the chaotic orbits produces a vertical segregation of both chaotic and non-chaotic orbits in the halo. Certain z_{max}, z_{min} are preferred by the chaotic orbits over others as a result of the conservation of the total orbital energy and of the interaction and confinement of the chaotic orbits by the principal families of periodic orbits (Figure 1). Some of these periodic orbits have been identified. Correlations between the structure found in the observed W distribution and that of the numerically determined z_{max}, z_{min} histograms are shown for our sample of 280 halo stars (Schuster et al. 1993). W is the star's velocity perpendicular to the Galactic plane and z_{max}, z_{min} the maximum distances above or below the Galactic plane, respectively, reached by the star in the course of its orbit. This vertical structure may explain certain puzzling observations of the galactic halo, such as conflicting c/a values for the shape of the halo, and unusual velocity dispersions and/or distributions near the Galactic poles. These results are in good agreement with Hartwick's (1987) two component model for the halo.

Our main conclusions are as follows: 1. Chaotic scattering of Galactic halo stars can serve to hide or destroy correlations involving kinematic parameters, such as a possible chemical gradient in the halo. 2. Due to these chaotic processes, as well as to the coupling of vertical and horizontal motions, the W velocity component of halo stars does not give a good indication of the maximum height above or below the Galactic plane reached by a halo star in the course of its orbit. 3. Vertical Poincare sections (Figure 2) provide a good means of studying the effects of chaos as well as

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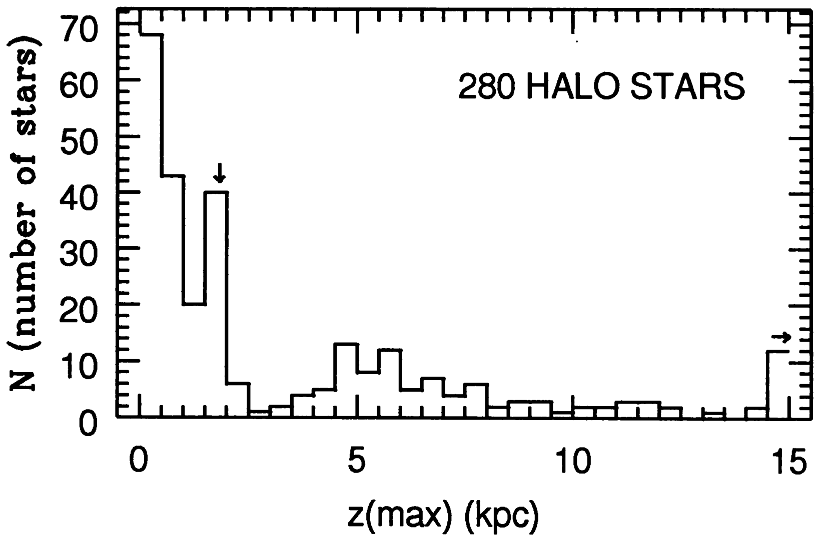

Figure 1. The calculated z_{max} histogram for the 280 halo stars obtained using the Galactic potential of Allen & Santillán (1991) with each orbit integrated for at least 15 radial or vertical oscillations. A minimum in the histogram is observed over the interval 2.5-3.0 kpc and a secondary maximum over 1.5-2.0 pc. This secondary peak is produced mainly by stars with chaotic orbits.

the velocity dispersions produced at the Galactic Poles by different Galactic potentials. 4. The observed W histogram for our 280 halo stars, the calculated z_{max} histogram, and various vertical Poincare sections all show structure, evidence for the interaction and confinement of chaotic orbits by families of periodic orbits. 5. Such interactions and confinements may help to explain the non-Gaussian "clumping in velocity space" that has been observed for halo stars near the Galactic Poles (Norris 1986), the possible existence of "moving groups" within the halo, as well as the differing shapes and velocity dispersions obtained for the galactic halo from different stellar samples.

References

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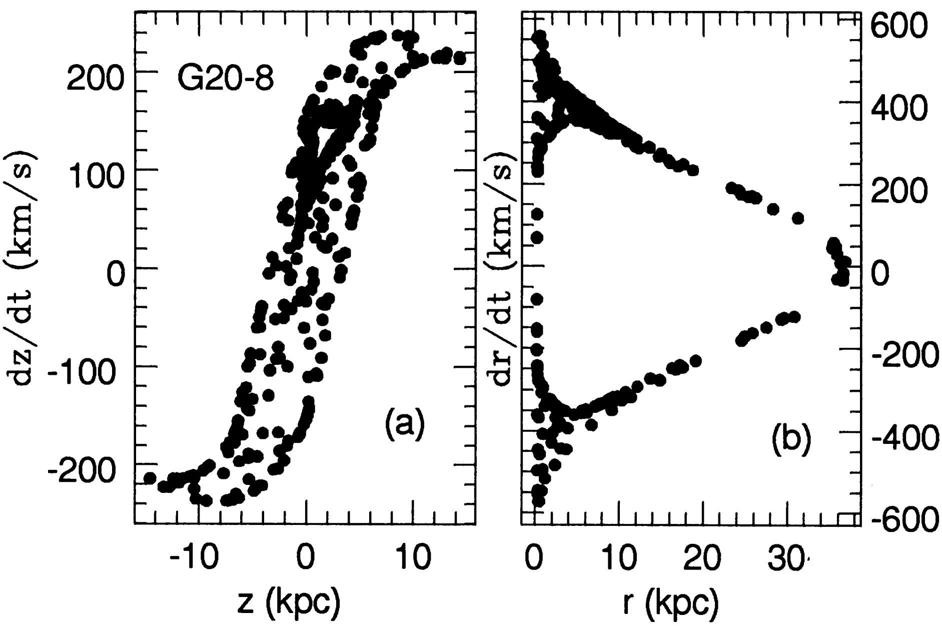

Figure 2. Vertical and horizontal Poincare sections for the halo star G20-8, which has a chaotic orbit. The vertical Poincare section (a) plots the W=dz/dt velocity against the vertical height each time the star crosses the Sun's radial distance traveling outward, while the horizontal Poincare section (b) the Galactocentric radial velocity against the radial position each time the star crosses the Galactic plane traveling upward.