THE ROTATION OF THE SOLAR CORE INFERRED BY GENETIC FORWARD MODELING

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Abstract

Genetic Forward Modeling is a genetic algorithm-based modeling technique that can be used to perform helioseismic inversions of the Sun's internal angular velocity profile. The method can easily accommodate constraints such as positivity and monotonicity, and readily lends itself to the use of robust statistical estimators of goodness-of-fit. After briefly describing the technique, we ascertain its performance by carrying out a series of inversions for artificial splitting data generated from a set of synthetic internal rotation profiles characterized by various small inward increases in angular velocity in the deep solar core ($r/R_\odot \leq 0.5$). These experiments indicate that the technique is accurate down to $r/R_\odot \simeq 0.2$, and retains useful sensitivity down to $r/R_\odot \simeq 0.1$.

We then use genetic forward modeling in conjunction with the LOWL 2-year frequency splitting dataset to determine the rotation rate in the deep solar core. We perform a large set of 1-D and 1.5-D inversions, using regularized least-squares minimization, conventional least-square minimization with a monotonicity constraint ($\partial\Omega/\partial r \leq 0$), and inversions using robust statistical estimators. These calculations indicate that the solar core rotates very nearly rigidly down to $r/R_\odot \sim 0.1$. More specifically, on spatial scales $\gtrsim 0.04\, R_\odot$ we can rule out inward increases by more than 50% down to $r/R_\odot = 0.2$, and by more than a factor of two down to $r/R_\odot = 0.1$. Thorough testing of various possible sources of bias associated with our technique indicates that these results are robust with respect to intrinsic modeling assumptions. Consequences of our results for models of the rotational evolution of the Sun and solar-type stars are discussed.