Induced Amino Acid Chirality from Strong Magnetic Fields in Interstellar Environments

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Recent work [1,2] has suggested that the chirality of the amino acids could be established in the magnetic field of a nascent neutron star from a core-collapse supernova via processing by the neutrinos that would be emitted. This model, the Supernova Neutrino Amino Acid Processing Model, or SNAAP model, not only appears to produce a small chiral imbalance, but al-ways produces the same sign of the chirality. This is also consistent with evidence that the origin of amino acid chirality may be non-terrestrial in nature [3,4,5].

We have studied the capability of the SNAAP model for selective destruction of one molecular chirality. This extends previous work [2] to include the dynamical effects that would be produced on the amino acids that were included in meteoroids that were large enough to escape destruction by the supernova photons as they passed by a nascent neutron star. This model has many similarities to nuclear magnetic resonance, even though it is essentially classical. The study does show that the amino acids contained in a large meteoroid could undergo orientation from the magnetic field of the neutron star, subsequent chiral sub-state selection from the combination of that field and the rotation of the meteoroids, and finally chiral selection by the neutrinos emitted as the neutron star produced by a core-collapse supernova cools over its characteristic few second cooling time.

A Monte Carlo code was written to simulate strong neutrino interactions with amino acids in the vicinity of neutron stars [6]. This model assumes that the neutrinos emitted from the nascent neutron star would interact with the amino acids, which had been oriented by the neutron stars magnetic field. These molecules would have to be contained in large meteoroids that happened to be passing by the star as it became a supernova, so that they could survive the high temperature environment existing near the star. The crucial interaction that destroys ^{14}N is $^{14}N + \nu_e \rightarrow {}^{14}C + e^+$. It was also assumed that some imbalance in the total angular momentum of the molecules would be achieved, perhaps by the Buckingham effect [7,8], so that the conversion of ^{14}N to ^{14}C would, because of a spin selection effect on the strength of the interaction, selectively destroy one orientation compared to the other. These amino acids would have to be contained in large meteoroids that happened to be passing by the star as it became a supernova, so that they could survive the high temperature environment existing near the star.

For this study, the bulk polarization of ^{14}N was calculated for various meteoroid impact parameters (distance of closest approach), speeds, rotational speeds, and neutron star magnetic field. A subset of results are shown in Figure 1 for various impact parameters. Coupling the nitrogen spin to the molecular spin can result in a bulk molecular polarization coupling to the overall chirality.

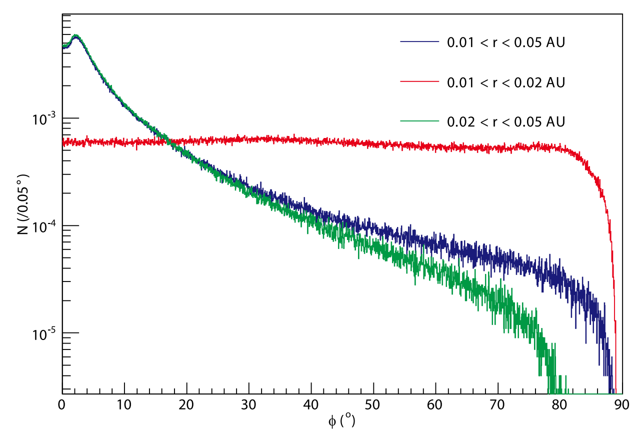

Figure 1: Polarization angle distributions for three models which vary by distance of closest approach.

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