The Feedback Ladder in Star Formation: Turbulence, Cloud Disruption, and the 'Galactic Ecology'

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Sky surveys with satellites and ground based telescopes are providing a detailed view of the cycling of gas from the interstellar medium into stars and back into the interstellar medium - the ***Galactic ecology***. The ecology is powered by galactic spiral structure, energetic feedback from forming stars, and super-bubbles created by the ionizing radiation emitted by massive stars and their demise in supernova explosions. I will review the ***feedback ladder*** which self-regulates the birth of stars and star clusters, keeps the efficiency of star formation low, and provides an important mechanism for the generation of interstellar turbulence and cloud destruction.

Shock-waves driven by spiral structure and super-bubbles can also compress interstellar gas to form new dense molecular clouds which produce new stars. In the Solar vicinity, atoms cycle from cold, gravitationally bound, and star-forming molecular clouds, into hot ionized plasma, and back into cold clouds on a time-scale of 10^8 years. During, each cycle, atoms have only a few percent chance of being incorporated into a star. Thus, atoms can survive in the interstellar gas for tens of cycles (few x 10^9 years) before being incorporated into a star.

The Solar system is currently passing through an inter-arm spur of the Milky Way galaxy where the Galactic ecology is dominated by nested super-bubbles carved out of the interstellar medium by nearby, young ($< 2 \times 10^7$ year old) associations of massive stars such as those in Orion and the Scorpius-Centaurus regions and older ($< 10^8$ year old) 'fossil' associations such as the Cassiopeia-Perseus-Taurus group. The largest-scale ISM gas, dust, and radio continuum features of the local (within 1500 light-years of the Sun) sky can be understood as bubbles created by these stellar associations. The Sun is currently moving through the outskirts of the Scorpius-Centaurus super-bubble which appears as a two-steradian feature in all-sky maps.

Detailed understanding of our Galactic ecology will serve as a template for the interpretation of the emission from galaxies in the distant Universe where individual star forming complexes and dust structures cannot be resolved.