Joint Institute for Nuclear Astrophysics

Thermal Conduction and the Production of Mixed-Morphology Supernova Remnants

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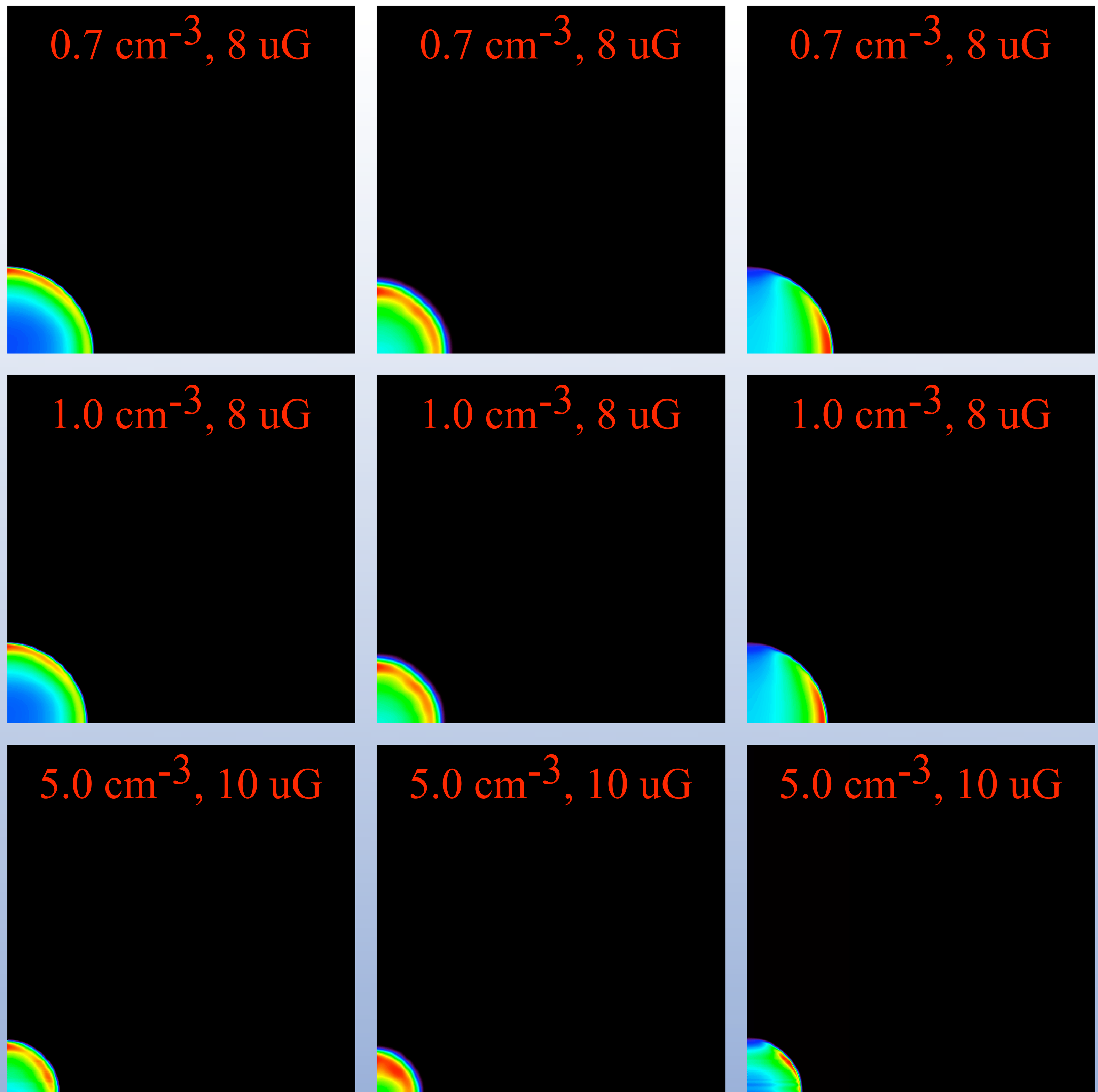

Figure 1: 300 eV bremsstrahlung (left), 3 keV bremsstrahlung (middle), and synchrotron (right) emission calculated for our simulations without thermal conduction after 80 kyrs. These remnants appear shell-bright in both x-rays and radio.

The expansion of a supernova remnant into the interstellar medium is driven by the hot interior of the remnant. The transfer of heat away from the remnant, whether from radiative losses or thermal conduction, plays an important role in determining the evolution of the remnant.

We present early results from a series of numerical simulations examining the combined role of anisotropic thermal conduction and radiative cooling of a supernova remnant in a variety of environments. The fluid equations are solved using the RIEMANN code (Balsara 1998, Balsara & Spicer 1999). Heating and cooling rates are calculated using the cooling models of MacDonald & Bailey (1981). Thermal conduction is calculated using a time-implicit method with a built-in flux limiter that tops out the heat flux at the saturated value (Cowie & McKee 1977, Slavin & Cox 1992, Shelton 1999). In the presence of a magnetic field, the heat flux becomes anisotropic (Balbus 1986) as the heat flux carried by hot electrons does not transfer further perpendicular to the field than the electron gyroradius.

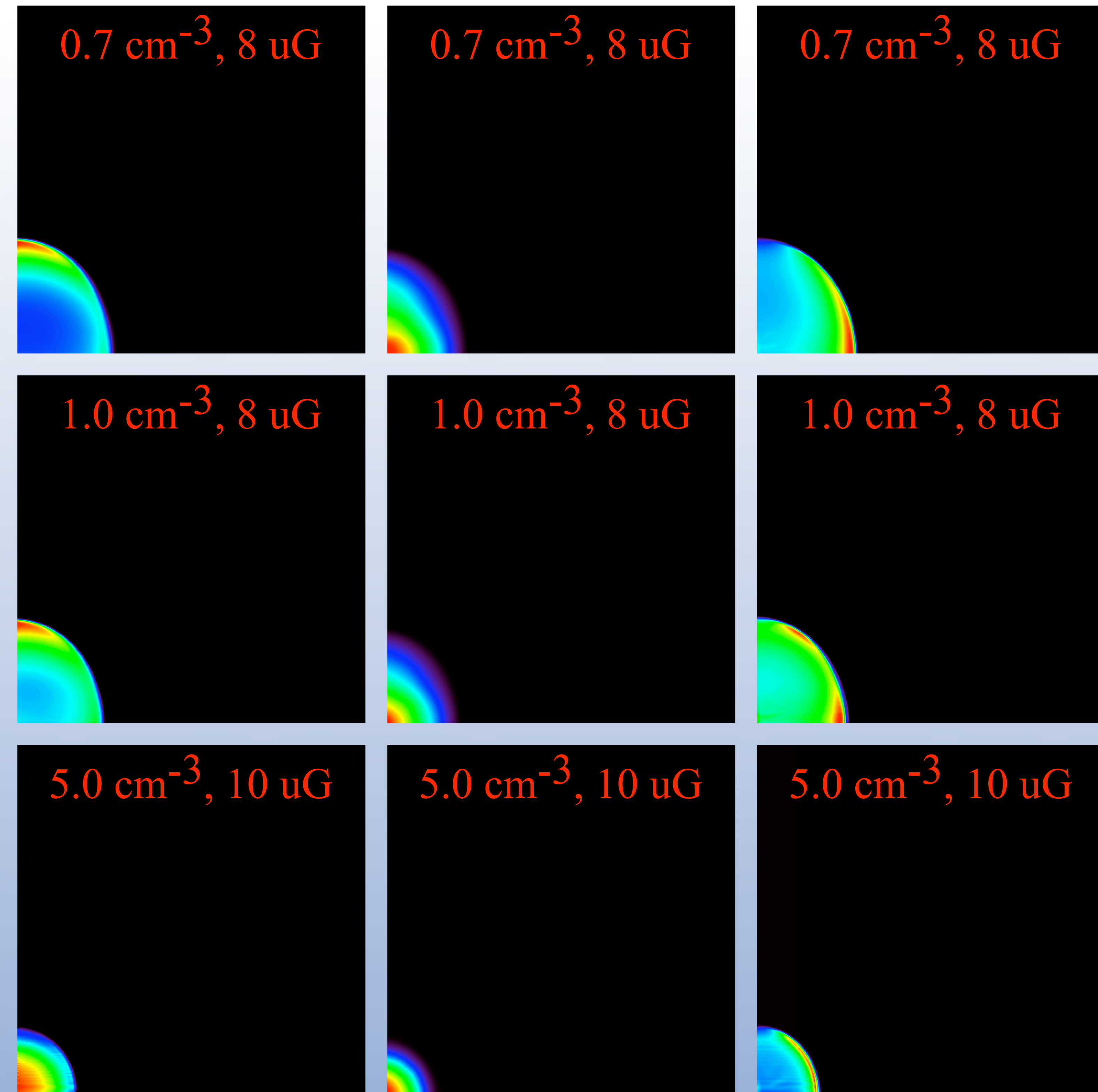

Figure 2: 300 eV bremsstrahlung (left), 3 keV bremsstrahlung (middle), and synchrotron (right) emission calculated for our simulations with thermal conduction after 80 kyrs. The presence of thermal conduction leads to greater emission from the hot bubble in x-rays, especially in higher-density media.

The presence of thermal conduction decreases the temperature of the hot gas bubble of the SNR; this is accompanied by an increase in the density of the gas. Consequently, the x-ray emission can be significantly brighter in the centres of these remnants if the density is sufficiently large (Fig. 2). This provides a possible explanation for the difference between classical shell-type SNRs and mixed-morphology remnants. Shell remnants would be primarily produced in lower-density environments,while mixed-morphology remnants would appear in higher-density locales.

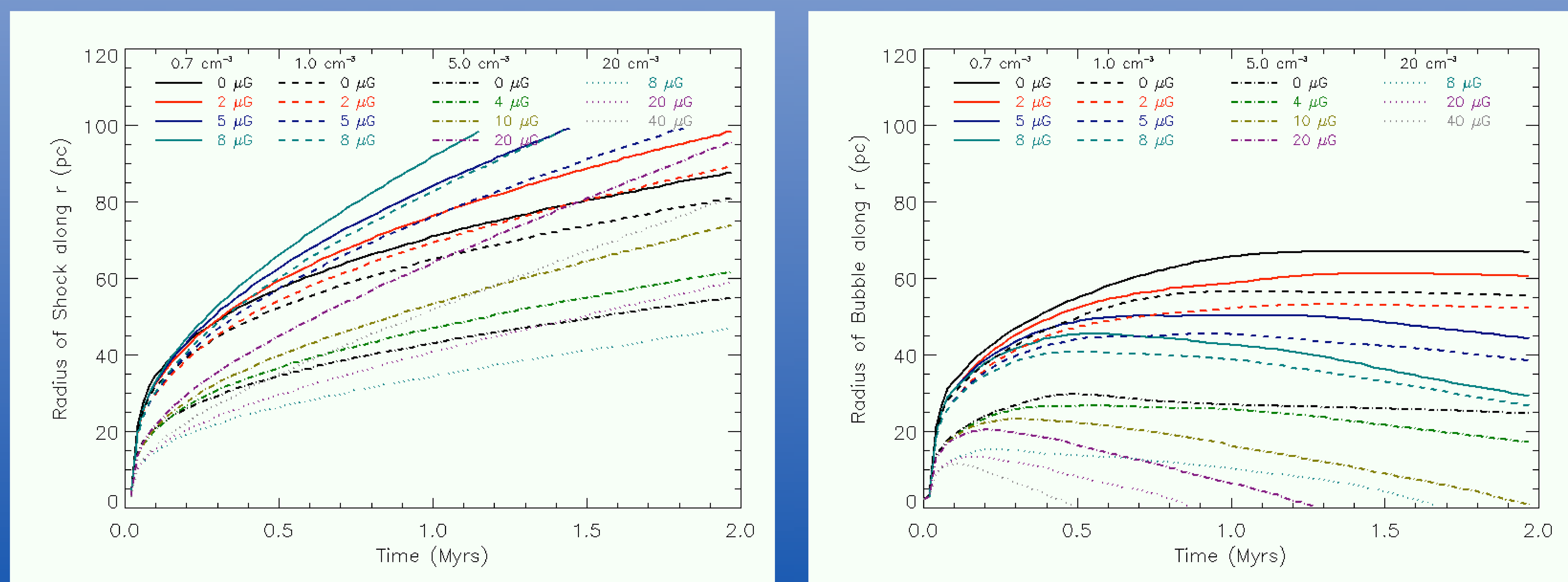

Figure 3: The role of the environment on the evolution of the outer shock (left) and the size of the hot bubble (> 10^5 K). Higher densities lead to increased cooling and an increase pressure that collapses the hot gas quicker than in lower-density environments.

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