The Chemical Impact of an Active Sgr A*

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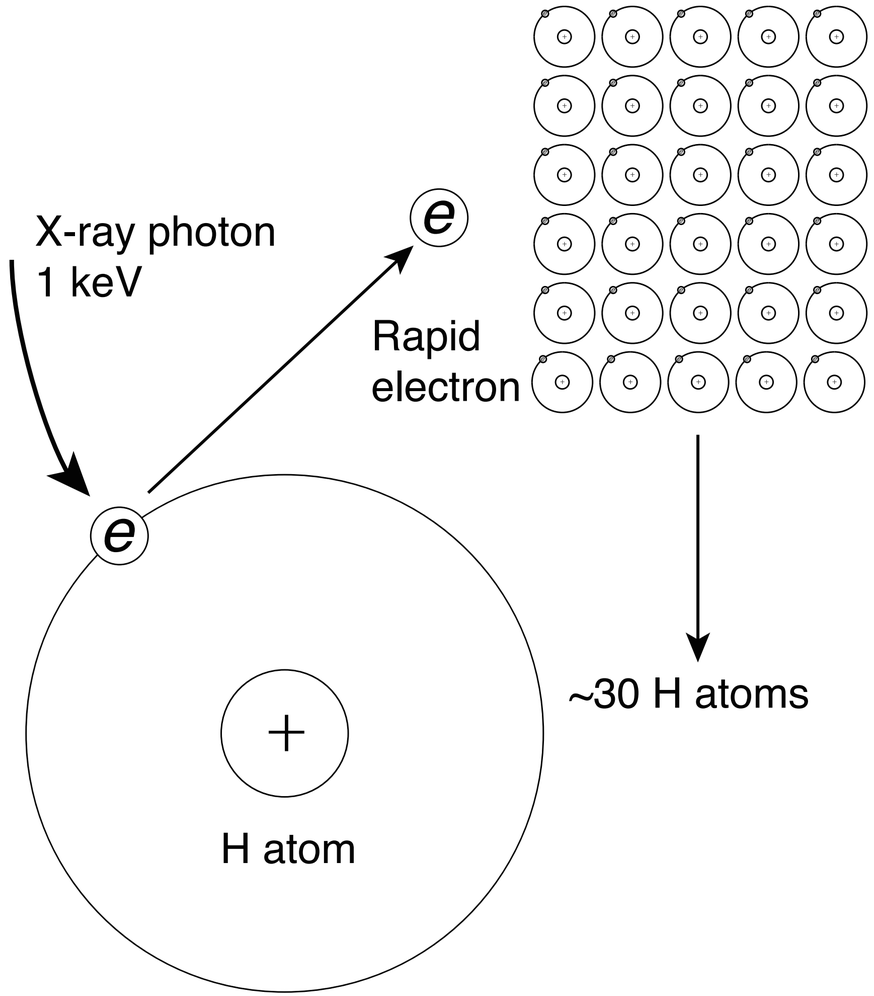
Introduction

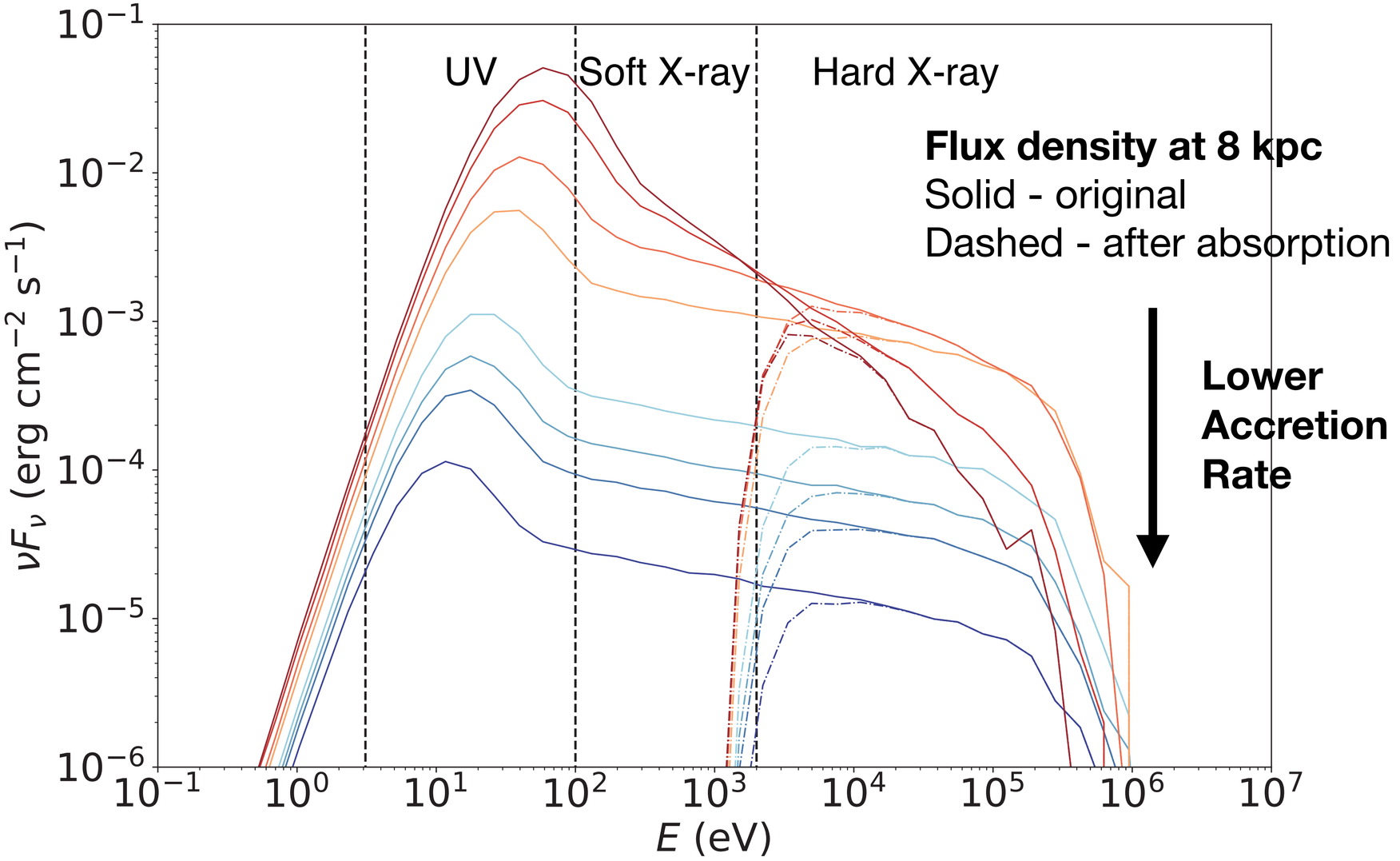
- Supermassive black holes are ubiquitous in massive galaxies
- **Multiple episodes of gas accretion** - every 10-100 Myr
- **Sgr A*** in the Milky Way
  - Underwent accretion **only 6 Myr** ago
  - Highly energetic radiation
    - Penetrate the dusty galactic disk efficiently
    - **Chemical impacts**

Introduction

- AGN induced chemistry in molecular clouds
  - X-ray ionization
    - Rapid electrons ejection
    - Secondary ionization
  - Synthesis of **organic molecules**
  - **Evolution of life?**



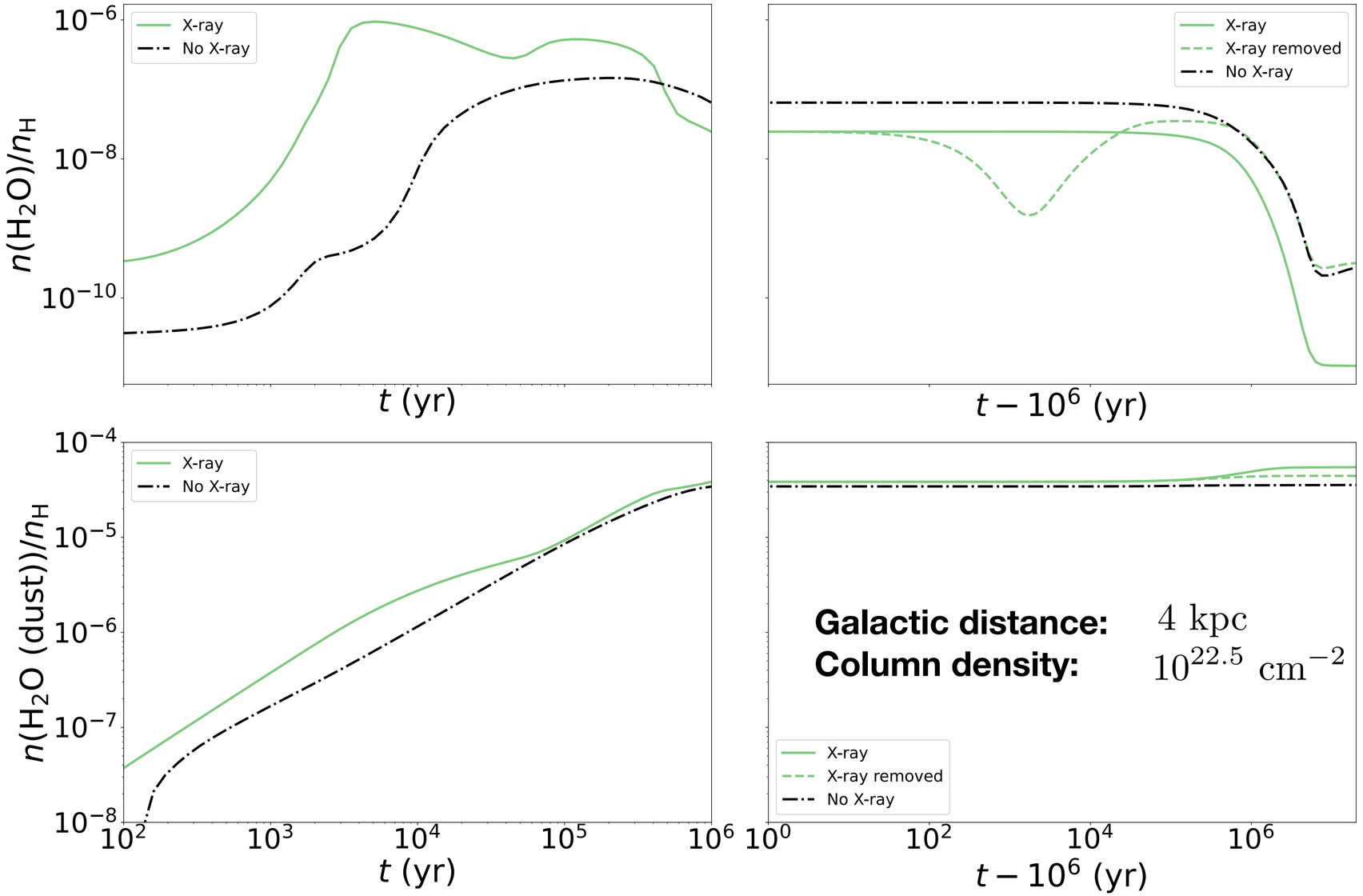
Methods


UV
Soft X-ray
Hard X-ray
Flux density at 8 kpc
Solid - original
Dashed - after absorption
Lower Accretion Rate
νF_ν (erg cm^{-2} s^{-1})
E (eV)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}

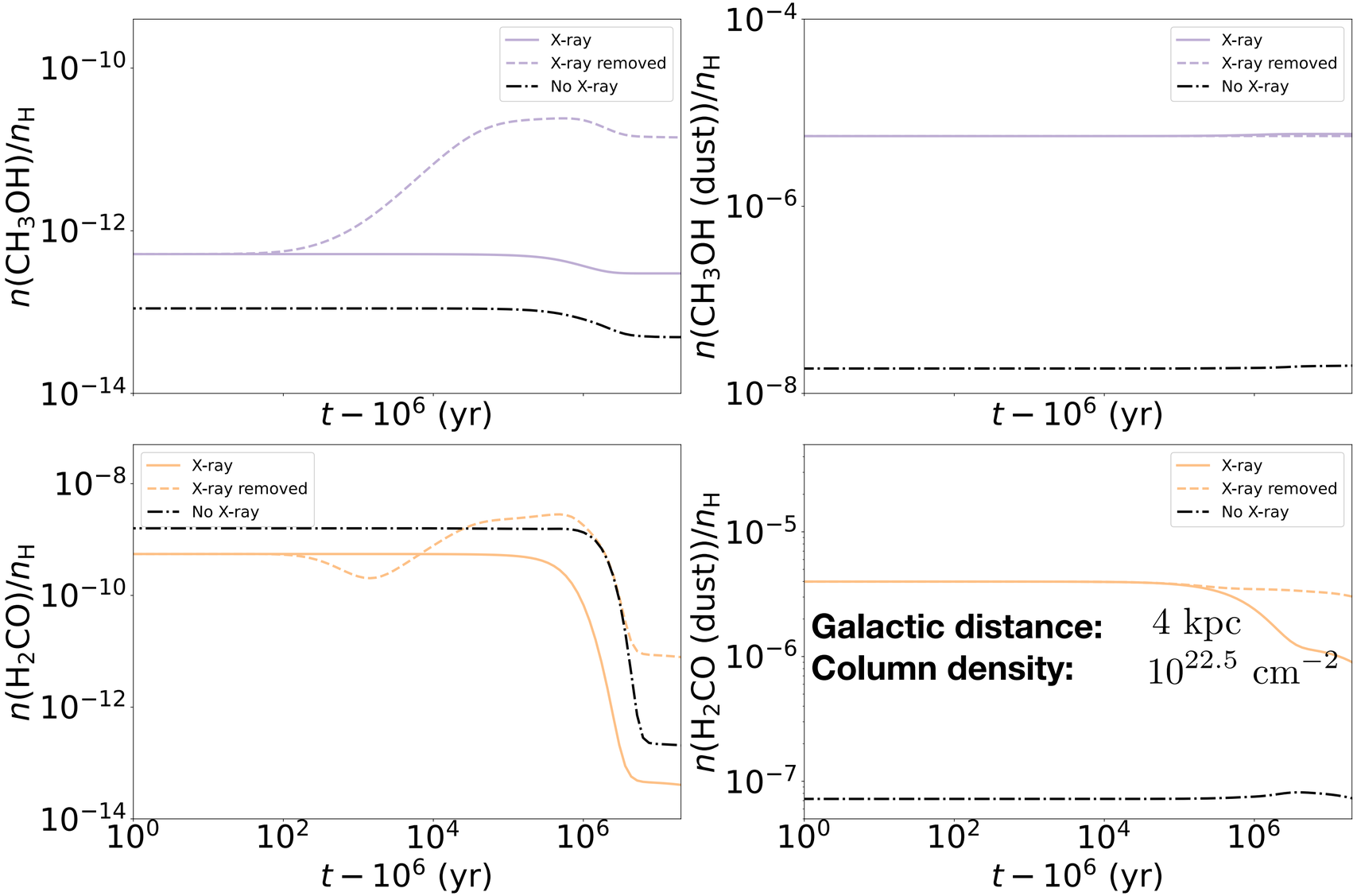
Fiducial Model

- Eddington accretion rate
- Galactic distance: $4\ \mathrm{kpc}$
- Column density: $10^{22.5}\ \mathrm{cm}^{-2}$
- Three molecules $\mathrm{H_2O},\ \mathrm{CH_3OH},\ \mathrm{H_2CO}$
- Two phases
  - Gas / grain

Fiducial Model: H_2O



Fiducial Model: CH_3OH & H_2CO



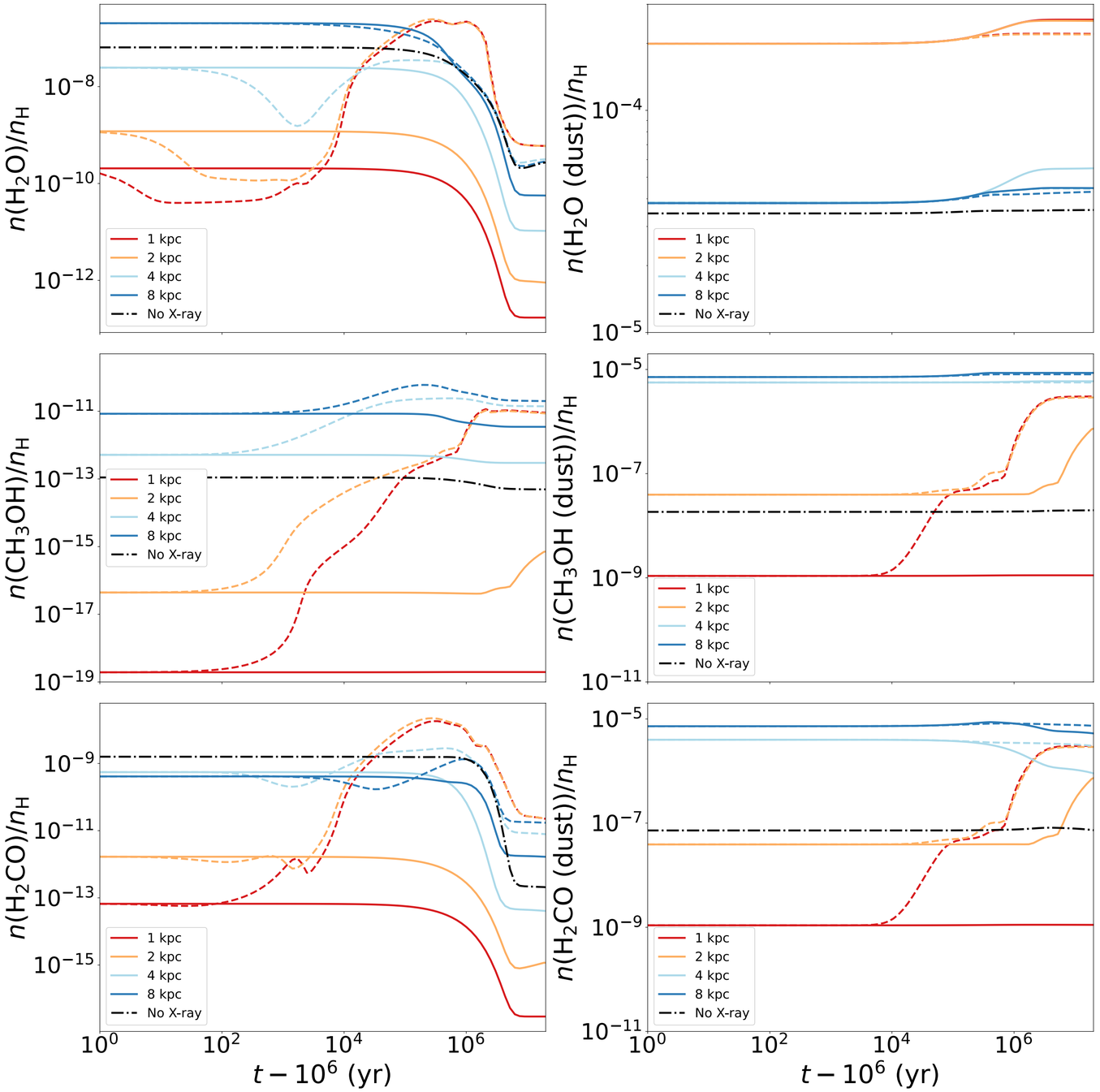
Galactic Distance

Galactic distance:

$1 - 8$ kpc

Column density:

$10^{22.5}$ cm^{-2}



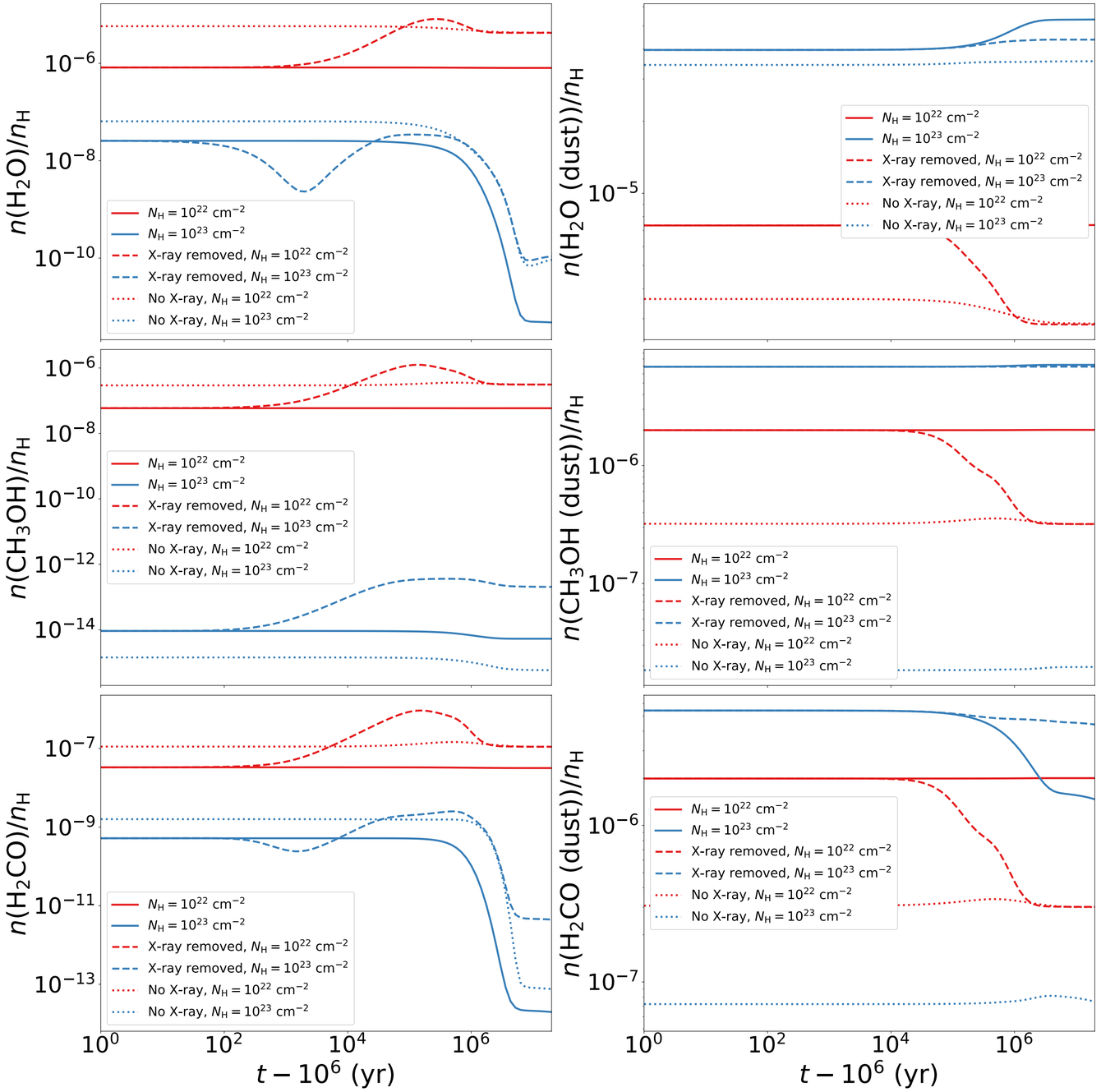
Inside Clouds

Galactic distance:

4 kpc

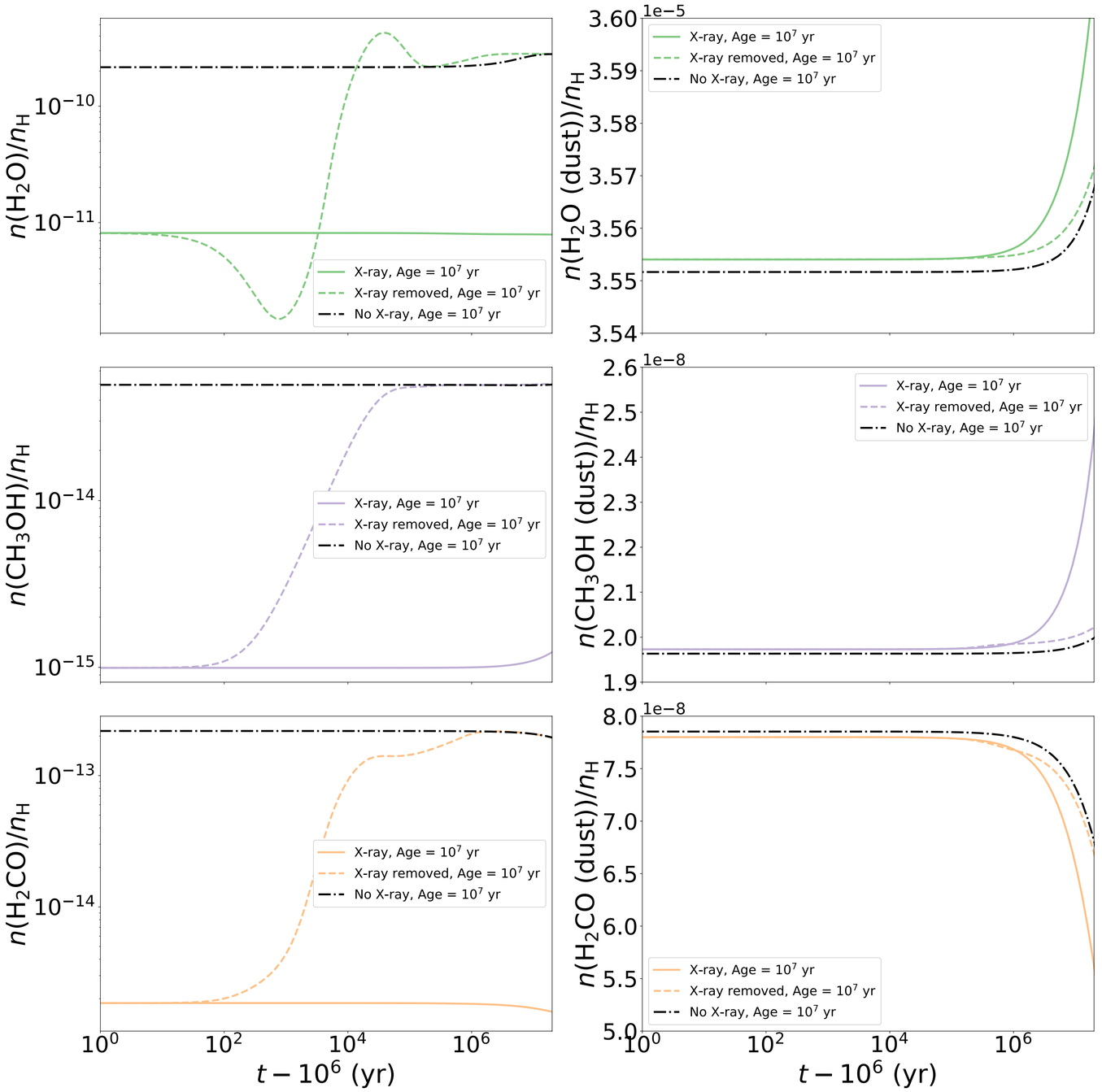
Column density:

10^{22-23} cm^{-2}

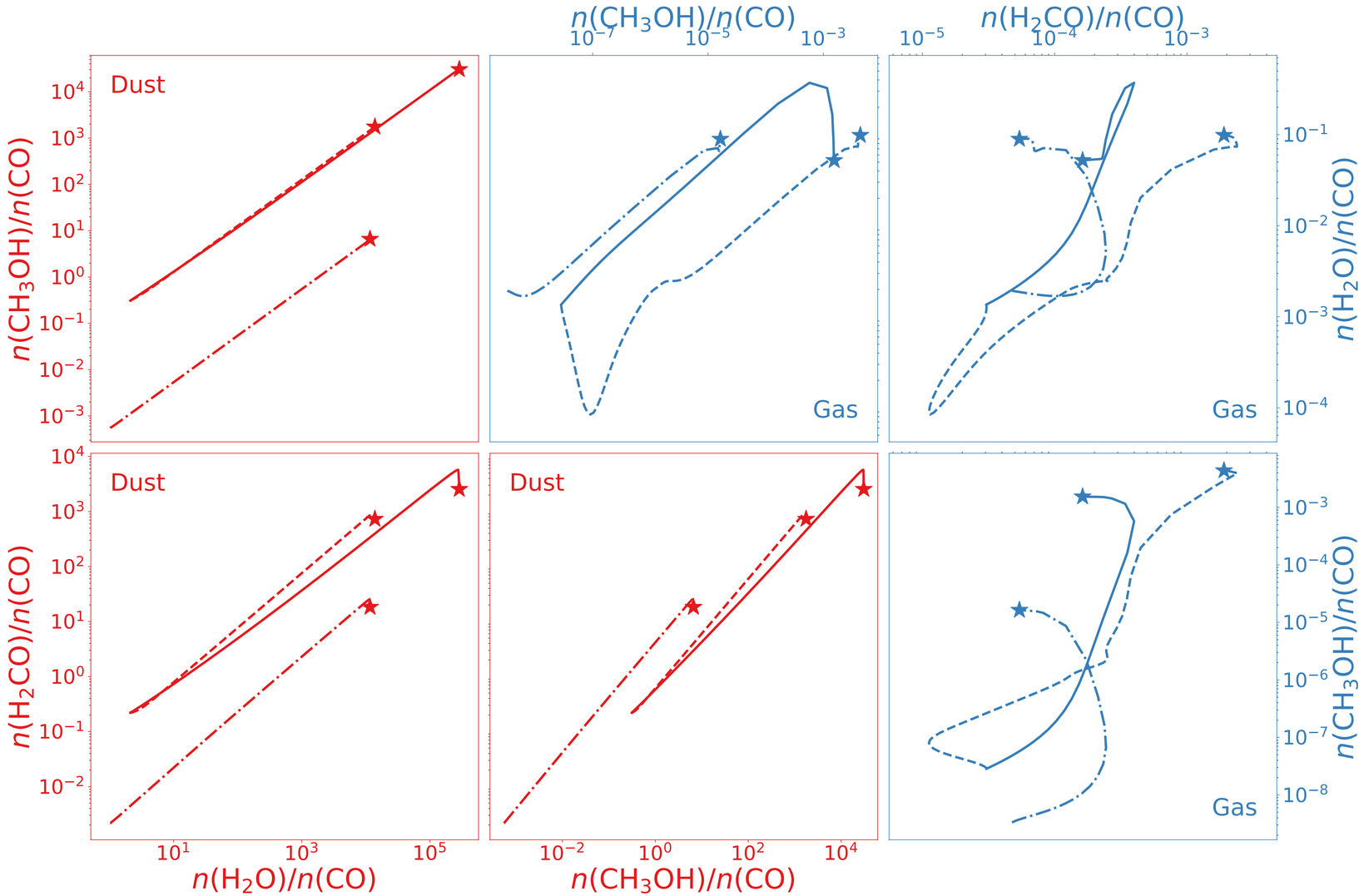


Age Of Clouds

10 Myr older



Diagnostics



Conclusions

- X-ray in an ancient accretion event could leave observable signs of abundance promotion for H_2O, CH_3OH and H_2CO
- For molecular clouds closer to the galactic center (< 2 kpc), gaseous abundances of H_2O and H_2CO in dense cores could exceed similar clouds farther away
- Evolved clouds do not show similar properties
- With submillimeter telescopes such as ALMA, we can conduct more archaeological studies of our galaxy in search of complex molecules

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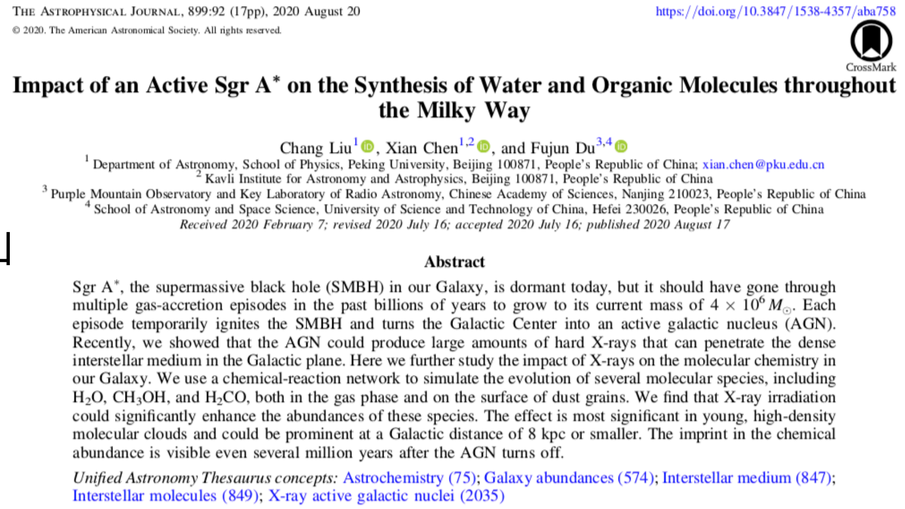

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Impact of an Active Sgr A* on the Synthesis of Water and Organic Molecules throughout the Milky Way

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Abstract

Sgr A*, the supermassive black hole (SMBH) in our Galaxy, is dormant today, but it should have gone through multiple gas-accretion episodes in the past billions of years to grow to its current mass of $4 \times 10^6 M_\odot$. Each episode temporarily ignites the SMBH and turns the Galactic Center into an active galactic nucleus (AGN). Recently, we showed that the AGN could produce large amounts of hard X-rays that can penetrate the dense interstellar medium in the Galactic plane. Here we further study the impact of X-rays on the molecular chemistry in our Galaxy. We use a chemical-reaction network to simulate the evolution of several molecular species, including H_2O, CH_3OH, and H_2CO, both in the gas phase and on the surface of dust grains. We find that X-ray irradiation could significantly enhance the abundances of these species. The effect is most significant in young, high-density molecular clouds and could be prominent at a Galactic distance of 8 kpc or smaller. The imprint in the chemical abundance is visible even several million years after the AGN turns off.

Unified Astronomy Thesaurus concepts: Astrochemistry (75); Galaxy abundances (574); Interstellar medium (847); Interstellar molecules (849); X-ray active galactic nuclei (2035)

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