Water in High-mass Protostars with Herschel/HIFI: Using H₂O line profiles to probe physical conditions

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ABSTRACT

Massive stars play a major role in the interstellar energy budget and the shaping of the galactic environment. However, the formation of high-mass stars is not well understood for several reasons: they are rare, they have a short evolution time scale, they are born deeply embedded, and they are far from us. The water molecule is thought to be a sensitive tracer of physical conditions and dynamics in star-forming regions because of its large abundance variations between hot and cold regions. Therefore, measurement of the water abundance is a step towards understanding the star formation process. We present Herschel/HIFI observations of water lines toward the high-mass protostellar objects to learn about physical processes in these regions and to identify links in the water abundance between the various evolutionary stages of high-mass star formation. This work is part of the guaranteed time key program Water In Star-forming regions with Herschel (WISH).

RESULTS & CONCLUSIONS

• Water detection in 5 high-mass protostars
  - 11 water lines in W3 IRS5 and AFGL2591
  - 8 water lines in IRAS18089-1732
  - 7 water lines in W33A
  - 5 water lines in IRAS18151-1208
  - p-H₂O 1₋0₋0ₐ (1113.3 GHz) line
  - emission line only in IRAS18151-1208
  - mix of emission and absorption lines in other sources
  - p-H₂O 2₋1₋1₁ (987.9 GHz) emission lines with 2 components in 5 sources
    - broad component by outflow
    - narrow component by envelope
  - No detection of H₂O and H₂O lines in IRAS18151-1208
    - due to optical depth effect
  - No detection of o-H₂O 3₋2₋0₉ (1097.4 GHz) line in W33A
    - not high temperature region to excite this line
  - Non-LTE models of AFGL 2591 indicate that
    - a gas density of > 10⁸ cm⁻³, a kinetic temperature of > 150 K for envelope
    - a gas density of > 10⁶ cm⁻³, a kinetic temperature of > 60 K for outflow

FUTURE WORK

• Calculate column densities and water abundances
• Compare o/p ratio and D/H ratio
• Full radiative transfer analysis (RATRAN)
• Analyze the HIFI map data

REFERENCES

• van der Tak et al. 2007, A&A, 468, 627
• van Dishoeck et al. 2011, PASP, 123, 138