

**CONTACT:  
DAG.HANSTORP@  
PHYSICS.GU.SE**

SYMPOSIUM ON  
**NEGATIVE IONS  
AND MOLECULES  
IN ASTROPHYSICS**

22-24 August 2011, Gothenburg, Sweden

In recent years, new telescopes have provided unprecedented opportunities to observe astrophysical objects with an improved sensitivity and resolution and in spectral regions that were previously inaccessible. A large number of molecules have been observed in the interstellar medium, giving rise to a completely new research field, astrochemistry, where chemical reactions in the interstellar medium are studied.

The symposium "Negative ions and Molecules in Astrophysics", arranged by the University of Gothenburg, intends to bring together physicists, chemists and astrophysicists with interest in this rapidly increasing interdisciplinary field. Any scientist interested in the field is invited to participate, and we do particular encourage younger researchers to attend.

**Topics**

- The chemistry of interstellar space
- Detection of anions in space
- Laboratory studies of interstellar processes
- Reaction dynamics and molecular spectroscopy
- Modeling of chemical reactions
- Astrochemistry outside our own galaxy

**Location**

- Department of Physics at the University of Gothenburg
- Visit to Onsala Space Observatory

**Information and registration**

Deadline for registration is June 27, 2011.

[http://www.science.gu.se/utbildning/utbildningar/forskarutbildning/tema/physical\\_sciences/negative-ions-and-molecules-in-astrophysics/](http://www.science.gu.se/utbildning/utbildningar/forskarutbildning/tema/physical_sciences/negative-ions-and-molecules-in-astrophysics/)

**Contact**

dag.hanstorp@physics.gu.se  
david.storek@physics.gu.se



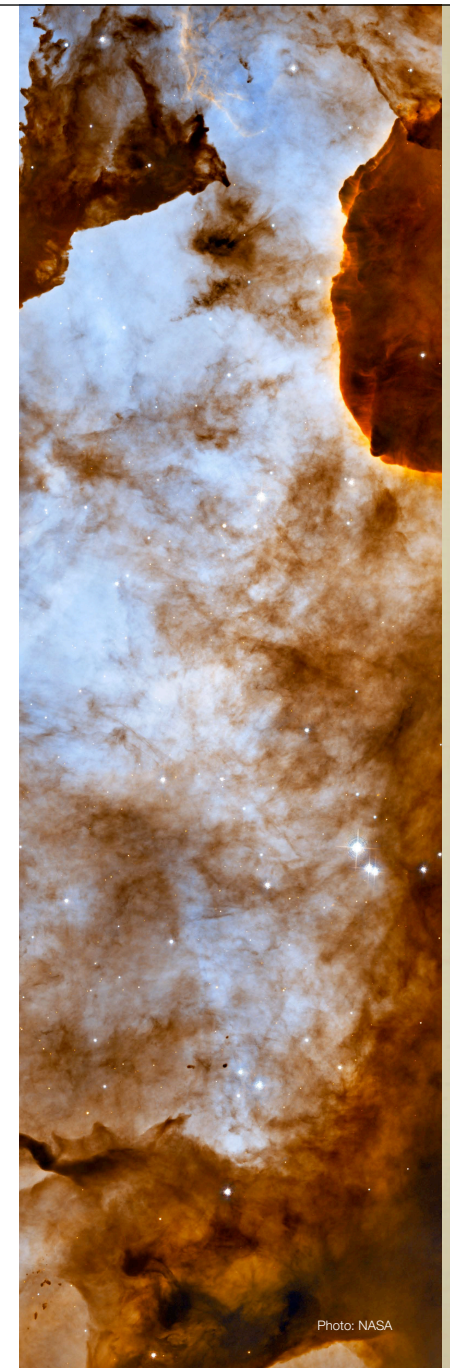
UNIVERSITY OF  
GOTHENBURG

**CHALMERS**

Nano Connect Scandinavia | [www.nano-connect.org](http://www.nano-connect.org)



Photo: NASA

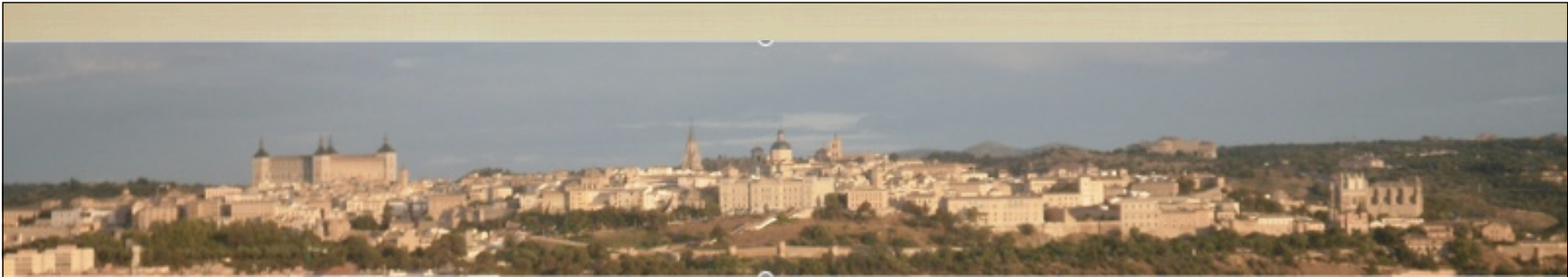


# CONFERENCE SUMMARY

**JOHN H. BLACK**  
DEPT. OF EARTH & SPACE  
SCIENCES  
CHALMERS UNIVERSITY OF  
TECHNOLOGY, SWEDEN

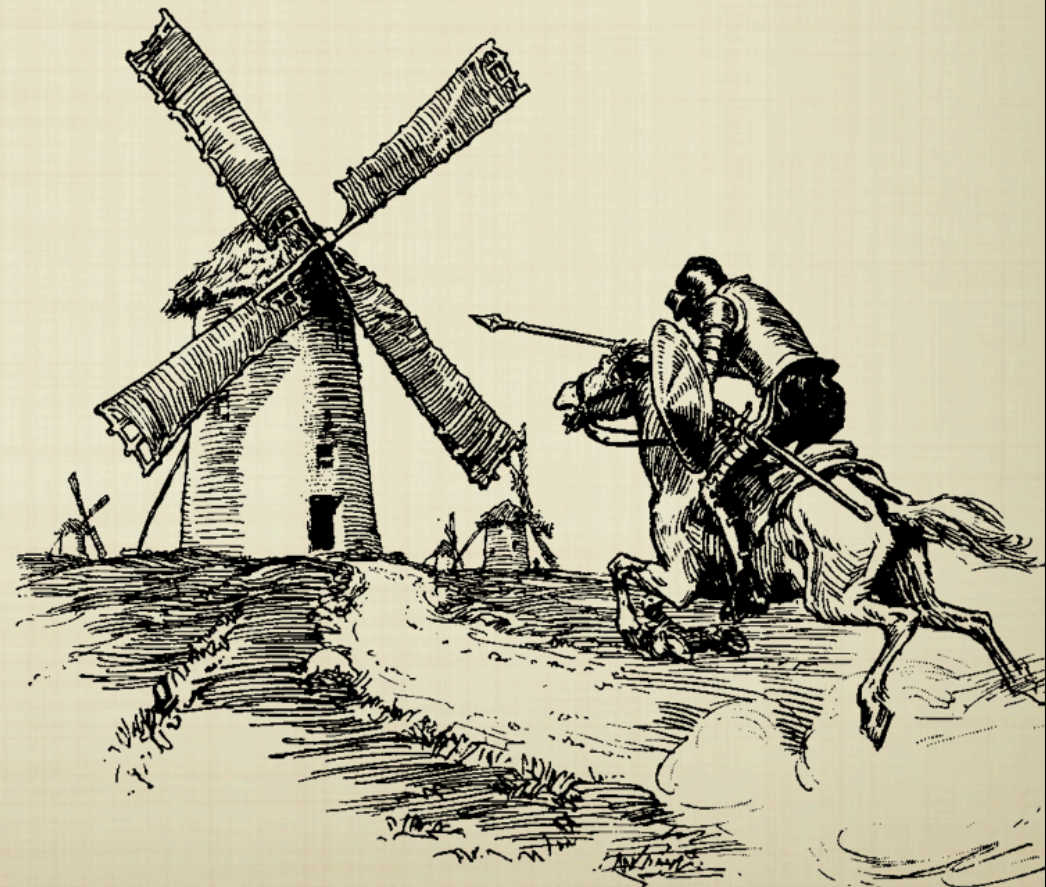






**440 PARTICIPANTS**  
**25 COUNTRIES**  
**74 PRESENTATIONS\***  
**322 POSTERS**

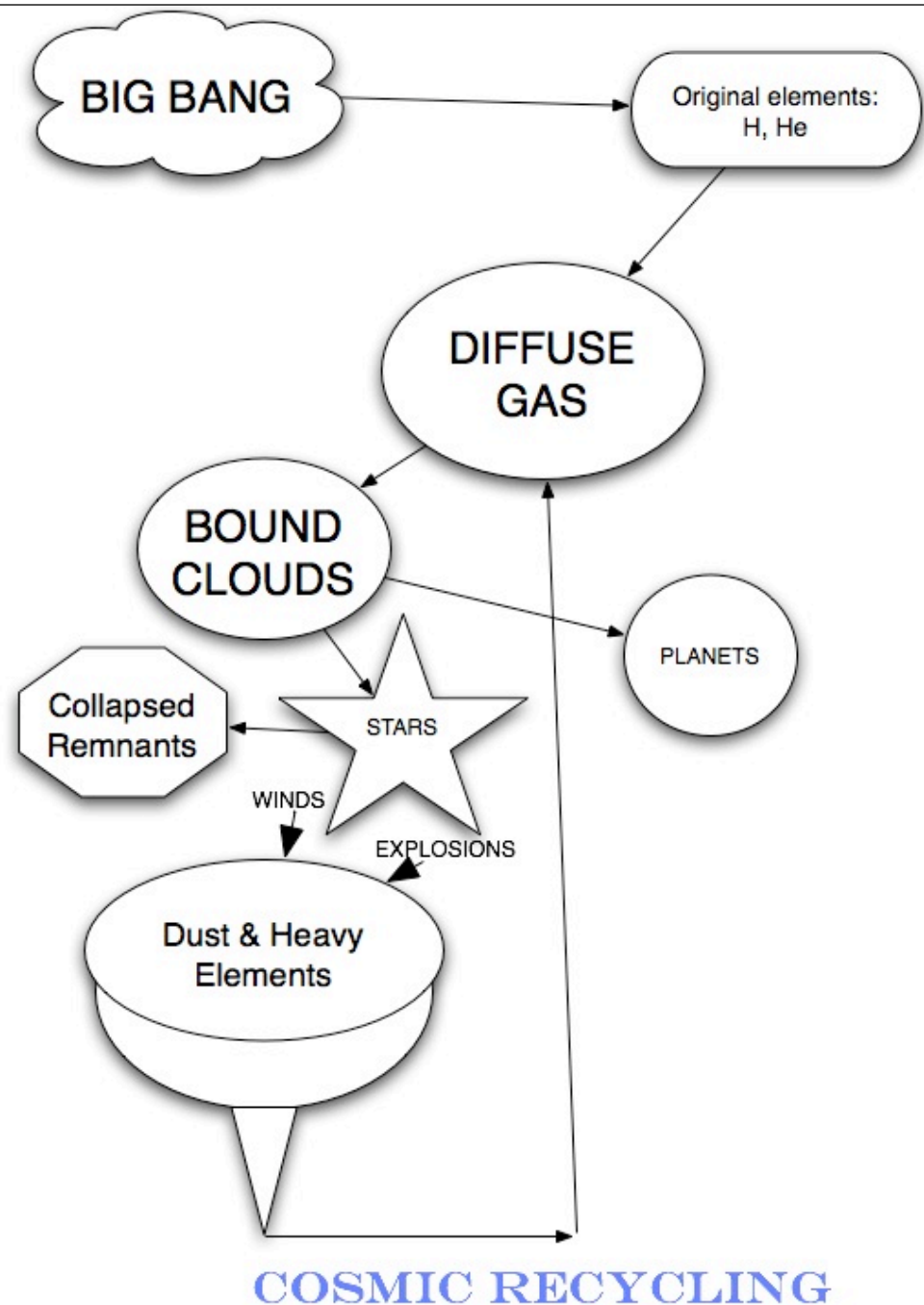
**\* 1 UNDER EMBARGO**



**ASTROCHEMISTRY:  
CONCERNED WITH  
ALL ASPECTS OF  
COSMIC EVOLUTION**

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**THE MOLECULAR  
UNIVERSE IS  
INTERESTING  
BECAUSE SO MUCH  
OF IT IS OUT OF  
EQUILIBRIUM**





- **MANY YOUNG PEOPLE HERE: THE FUTURE OF ASTROCHEMISTRY SEEMS BRIGHT...IF THERE WILL BE ENOUGH JOBS**
- **LARGE, INTERNATIONAL COLLABORATIONS ARE CHANGING THE MANNER OF RESEARCH**
- **DATABASES AND DATA ARCHIVES, EXPANDING AND FREELY SHARED**
- **OBSERVATIONS ARE OUTRUNNING THEORY AND MODELS**
- **LABORATORY: REAL CHEMISTRY & PHYSICS; MEASUREMENTS DESERVE PROPER CREDIT**

## THE THRILL OF DISCOVERY IS IN THE AIR

- A FLOOD OF IMPORTANT RESULTS FROM HERSCHEL (INTERSTELLAR MATTER, STAR-FORMING REGIONS, PROTO-PLANETARY DISKS, CIRCUMSTELLAR ENVELOPES, ETC.)
- COMMISSIONING DATA FROM ALMA JUST RELEASED; EARLY-SCIENCE PROPOSALS DUE AT THE END OF THIS MONTH

## WHAT'S NEW?!

- FULLERENES  $C_{60}$  AND  $C_{70}$  DISCOVERED!
- NEW, IMPORTANT INTERSTELLAR MOLECULES  $OH^+$ ,  $H_2O^+$ ,  $SH^+$ ,  $H_2CL^+$
- HIGH-BANDWIDTH RECEIVERS REVOLUTIONIZE RADIO SPECTROSCOPY
- MANY MARVELOUS LAB EXPERIMENTS
- ANIONS



## PANCHROMATIC APPROACHES

- X-RAY ABSORPTION - TOTAL ABUNDANCES
- ULTRAVIOLET - NEW CAPABILITIES WITH HST/COS; CO FLUORESCENCE IN DISKS, ABSORPTION SPECTROSCOPY OF THICKER CLOUDS. T TAU STARS WITH DISKS ARE OBSERVED IN UV(MODELLERS TAKE NOTE!)
- HIGH-ENERGY ASTROPARTICLE PHYSICS: - RAYS, COSMIC RAYS, INTERSTELLAR IONIZATION -  $\text{H}_3^+$  ABSORPTION (IR) AND  $\text{OH}^+$ ,  $\text{H}_2\text{O}^+$  (SUBMM)
- COUPLE ELECTRONIC, VIBRATIONAL, ROTATIONAL SPECTRA



## MODELS

- NEW, IMPROVED METHODS OF RADIATIVE TRANSFER; SPECTRUM ANALYSIS OF  $10^5$  LINES IN ORION
- MODELS OF PHOTON-DOMINATED REGIONS (PDR) COUPLED WITH HYDRODYNAMICS, ICE PROCESSING, GRAIN GROWTH, STOCHASTIC SURFACE CHEMISTRY, FRACTAL STRUCTURE
- BENCHMARK YOUR MODELS OF EXOPLANET ATMOSPHERES AGAINST A  $1 M_J$  PLANET AT 5 AU FROM A G2 V STAR (REMEMBER THE UV/EUV SPECTRUM OF THE SUN IS KNOWN)

# WATER

- **WHERE IS THE WATER IN LOW-MASS YOUNG STELLAR OBJECTS? (LOW-MASS CORES ARE DRY)**
- **ICE IN THE LAB, ICE IN SPACE**
- **WHERE DID THE WATER ON EARTH ORIGINATE? WATER IN THE SATURN SYSTEM**
- **ORTHO/PARA RATIOS IN COMETS, PROTOPLANETARY DISKS - LONG-TERM MIXING OF WARM/COLD REGIONS. HDO/H<sub>2</sub>O??**

*Water, water everywhere nor any drop to drink*



## SOLAR SYSTEM

- METEORITICS AND SAMPLE-RETURN MISSIONS
- MUCH EVIDENCE OF MIXING.
- PAHS ARE HERE, TOO
- ORGANIC GOO, BUT PROBABLY NOT PRIMORDIAL

## EVOLVED STARS

- EXTREMELY RICH SPECTRA OF MASS-LOSING STARS, BOTH CARBON- AND OXYGEN-RICH
- SPATIALLY RESOLVED HINTS ABOUT ANION CHEMISTRY; EVEN STARS ARE NOT SPHERICALLY SYMMETRIC (CF. VY CMA)
- AROMATIC IR BANDS NOT SEEN IN AGB STARS, BUT APPEAR IN PROTO-PLANETARY-NEBULAE\* (CHEMISTRY OR EXCITATION?)
- MOLECULES & DUST IN SUPERNOVAE

\*PLANETARY NEBULA - ONE OF MANY LABELS THAT ARE CONFUSING FOR NON-ASTRONOMERS



# EXOPLANETS AND THEIR ATMOSPHERES

- **ATMOSPHERE MODELS - DON'T NEGLECT MIXING (DIFFUSION) AND POSSIBLY EXTREME OUTER BOUNDARY CONDITIONS**
- **OBSERVATIONAL CHALLENGES, FUTURE TELESCOPES & SPACE MISSIONS**
- **EARTH-LIKE PLANETS, BIO-MARKERS**

# EARLY UNIVERSE AND FIRST STARS

- **PROGRESS ON BASIC PROCESSES**
- **OBSERVATIONAL TESTS WILL PUSH EVER CLOSER TO THE FIRST STARS**



## MOLECULES IN GALAXIES

- **BIG ADVANCE IN RECENT YEARS:  
ABUNDANCES CAN BE DETERMINED -  
ACCURATELY FROM ABSORPTION LINES AND  
BETTER NOW FROM EMISSION LINES FROM  
UNRESOLVED SOURCES. LINE SURVEYS**
- **MOLECULES ARE IMPORTANT PROBES OF THE  
MOST DISTANT GALAXIES AND QUASARS;  
GRAVITATIONAL LENSES MAKE 'NORMAL'  
GALAXIES DETECTABLE**
- **COSMOLOGICAL TESTS: ROLLING  
CONSTANTS,  $T_{\text{CMB}} \propto 2.725(1+z)^\alpha$  - IS  $\alpha=1$**

- **TURBULENCE - ANOTHER ASPECT OF NON-EQUILIBRIUM WITH IMPORTANT CONSEQUENCES FOR INTERSTELLAR CHEMISTRY AND DYNAMICS**
- **MAGNETIC PRE-CURSORS IN OUTFLOWS**



## THE PROMISE AND PERIL OF ALMA

- EVERY SPECTROSCOPIC OBSERVATION WILL BE A LINE SURVEY - HOW TO ANALYZE EVERYTHING!?
- IT MAY BE INCREASINGLY DIFFICULT FOR US TO SEE THE DETAILS AT HIGH RESOLUTION IN RELATION TO LARGER-SCALE STRUCTURES



**THANKS EVERYONE FOR A SPLENDID SYMPOSIUM!**

**AND SPECIAL THANKS TO THE  
LOCAL ORGANIZING COMMITTEE  
AND ALL SPONSORS**