4th Netherlands ALMA Science Day
Contributed Talk Abstracts

Alice S. Booth: "An inherited complex organic reservoir in a warm planet-hosting disk? First detection of methanol in a Herbig Ae/Be disk"

Interstellar ices, Class 0/I protostars and comets are all known to be rich in complex organic molecules (COMs). COMs are of particular astrochemical importance as they are the precursors of prebiotic molecules. Therefore, the search for COMs in Class II protoplanetary disks, where planetary systems are forming, is of great interest. A COM of particular significance is methanol (CH3OH), which is a feedstock for building higher complexity. CH3OH primarily forms at low temperatures on the surface of icy dust grains. So far, there is only one reported robust detection of CH3OH in a Class II disk, in the T Tauri disk TW Hya. It has been proposed that the disks around Herbig Ae/Be stars are COMs poor when compared to their T Tauri counterparts due to their warmer midplane temperatures and higher levels of UV irradiation. This claim has been supported by the non-detection of CH3OH in the well-studied HD 163296 disk. In this talk, I will present the first robust detection of CH3OH in a Herbig Ae/Be disk with ALMA Cycle 7 observations. I will compare this disk to other Class II disks where CH3OH has gone, so far, undetected. Finally, I will discuss several scenarios that could lead to the chemical origin of CH3OH in this disk, and the implications regarding our understanding of the origins of chemical complexity in disks.

Matus Rybak: "Full of Orions? Dissecting the extreme star-formation in the early Universe with ALMA"

Will a newborn star feel a difference between being born in Orion today, and in a massive, dusty galaxy 10 billion years ago? Forming stars at rates 100x higher than any present-day galaxy, the dust-enshrouded, sub-mm bright galaxies (SMGs) present a challenge to current models of galaxy evolution and formation. To uncover what processes drive these extreme star factories and how they impact the newborn stars, we need to study the physical conditions of their molecular gas. However, such studies at high redshift have been mostly limited to unresolved observations which mix different gas & dust phases and provide only a limited view of the physical conditions in the actual star-forming regions. I will present the recent results on a spectacular, strongly gravitationally lensed SMG SDP.81 (z=3.0). SDP.81 is probably the best-studied SMG, with 40+ hours of high-resolution ALMA observations across almost all Bands, including the 2014 Long Baseline Campaign. Combining extensive multi-tracer (dust, [CII], four CO lines) observations, uv-plane lens modelling, and radiative transfer models, I have mapped the physical conditions in an SMG just 2 billion years after the Big Band at an unprecedented, ~100 pc resolution. These *results provide the first view of the physical conditions in SMGs on scales comparable to nearby galaxies, how they vary across the galaxy, and reveal the extreme nature of its star-forming regions, with higher densities and stronger radiation fields than in the very heart of Orion.*

Pooneh Nazari: "Complex organic molecules in low-mass protostars"

Recently it has become apparent that planet formation starts at much earlier stages of star formation than thought before. Therefore, understanding the chemistry of planets depends on understanding the chemistry of these early stages, the Class 0/I phase. This contribution presents new data on the complex organic chemistry of two Class 0 sources in Serpens (S68N) and Perseus (B1-c) star forming regions with ALMA. The column densities and excitation temperatures of N-bearing and O-bearing complex organic molecules around these sources are determined using CASSIS spectral modelling tool. Within our spectral range, ten O-bearing and four N-bearing species with some of their isotopologues are detected. The column densities of the N-bearing species are typically an order of magnitude lower than that of the O-bearing species. The abundances of most molecules with respect to CH3OH are similar between different sources. The exceptions are NH2CHO, HNCO, CH3CHO, C2H5OH and CH2OHCHO where their abundances with respect to CH3OH differ by up to an order of magnitude. Some of the differences may be due to the sensitivity of the chemistry to local conditions. Alternatively, different emitting areas linked to the binding energies of species with respect to the ice can cause the variations in abundances. The excitation temperatures of the N-bearing and O-bearing species span a similar range (~100-300K) and are larger than the respective sublimation temperatures of each molecule. The excitation temperatures are likely reflecting the mass-weighted kinetic temperature for a gas density structure that follows a power-law. The two sources studied in this work add to the small number of protostars with such detailed chemical analysis on solar system scales. An increase in this number can cast a considerable light on our understanding of diversity of exoplanets. Also, using future JWST observations we can directly compare the gas phase abundances to solid state abundances.

Karina Caputi: "An ALMA galaxy signposting a MUSE galaxy group at z=4.3 behind El Gordo"

In this talk I will present our discovery of a MUSE galaxy group associated with an ALMA 1.2 mm source at z=4.3, all gravitationally lensed by the massive galaxy cluster El Gordo. I will show the derived properties of the different group components. While the ALMA galaxy is a typical main sequence galaxy, half of the MUSE companions are starbursts, i.e. have very high specific star formation rates. This starburst incidence is unusually high compared to what is known from the literature. I will discuss the potential cause and implications of this finding.

Ardjan Sturm: "Tracing outer disk carbon depletion using [CI]"

Recent work has pointed out that the carbon abundance in protoplanetary disks is not as constant as we thought, but the number of sources with known carbon depletion fraction is still small. Carbon depleting mechanisms lead to trends in C/H as function of time and radius, offering us more insight in the efficiency of dust traps and planetesimal formation processes. Following earlier work on carbon depletion, the aim of this research is to determine the carbon abundance in the outer disk of three T Tauri sources and estimating the efficiency of planetesimal formation and/or dust trapping in protoplanetary disks, based on the radial profile of carbon abundance. We observed band 8 [CI] in seven disks using ACA and modeled three of these disks using thermo-chemical DALI models to determine the carbon abundance in the outer disk. In this talk I will discuss the data analysis, the resulting complex line profiles and the modeling. We find depletion factors of ~5, ~10 and ~135 for DR Tau, DO Tau and DL Tau respectively, following similar trends in age as expected based on theoretical carbon depletion models. Comparing the carbon abundance in the outer disk with literature values of the inner disk carbon depletion, we find that planetesimal formation is potentially very efficient in compact systems."

Raffaella Morganti: "Taking snapshots of the jet-ISM interplay with ALMA: the case of PKS 0023–26"

Radio jets are a spectacular manifestation of the nuclear activity in galaxies. The energy they release can strongly impact the ISM/IGM. Interestingly, this interaction can be traced also by the molecular gas. The high spatial resolution of ALMA is, therefore, ideal to trace the details of this process. The way the radio plasma couples with the surrounding medium, the dependence on the jet power and whether this coupling changes as the jet expands, are all key parameters for quantifying their effect on the conditions of the ISM and, ultimately, on the evolution of their host galaxy. However, building a complete picture requires tracing the details of this interaction in a variety of radio sources to cover this large parameter space. Since Cycle 1 we are in the process of doing this, building up a small but rich sample. The latest target observed in Cycle 6 is the young radio galaxy PKS 0023-26. In this talk I will report the results of C(2-1) and 176 GHz continuum observations and what they are telling us about the way the radio plasma affects the kpc-scale gas. A comparison with the other objects in the sample is giving some hints on how such effects may change from pc to kpc scales.

Martijn van Gelder: "Modeling SO and SO2 in accretion shocks"

The material from which new solar systems are built originates from a gravitationally collapsing cloud of gas and dust. A major question is to what extent the chemical composition is preserved from cloud to disk ('inheritance'), or whether it will be modified en route ('reset') due to a strong accretion shock as the material enters the *disk. Recent high-angular resolution ALMA observations hint at shocks near the disk-envelope interface toward the youngest protostellar systems via the detection of warm SO and SO2. However, the interpretation of these millimeter data is ambiguous, since the emission could also be related to outflow activity and heating by the protostar. In this talk I will introduce a grid of shock models in different physical conditions to investigate whether the abundance of SO and SO2 increases in such shock and if so, how they can help us to constrain the strength of the shock. Only under a rather small (100 - 200 K) range of temperatures reached in the shock do the abundances of SO and SO2 increase significantly, in particular in high density environments with an intermediate radiation field. The dust temperature in these shocks only increases to ~30-40 K, high enough to release volatiles such as CO into the gas, but not stronger bound species such H2O and complex organic molecules. These results raise the need for additional high-angular resolution ALMA data using several shock tracers to observationally determine the characteristics of accretion shocks in order to find the amount of reset of the chemistry. In turn, this gives insight on the composition of material that enters the disk which eventually will be the building blocks of planets.*

Niels Ligterink: “Serpens SMM1-a: A primordial soup in space”

The formation of life as we know it may have an extraterrestrial component. Prebiotic molecules - species that are involved in the formation of biomolecules, such as amino acids and nucleobases - could have been delivered from space and kick-started life on Earth. To support this theory, detailed studies of the prebiotic molecular composition of young protostars are needed, since in these regions the planetary building blocks form that can incorporate these molecules and deliver them to planetary surfaces. In this talk, I will present results of ALMA observations of the Class 0 intermediate-mass protostar Serpens SMM1-a. Detections of prebiotic molecules in the line-rich spectra of this source are presented and the interstellar chemistry of these molecules is discussed. The results of these observations show that SMM1-a host a rich "primordial soup" that can contribute to the formation of biomolecules and thus start the formation of life.

Ko-Yun (Monica) Huang: “Characterizing the shock properties in NGC1068”

In our previous study with two well-known shock tracers, SiO and HNCO, in the circumnuclear disk (CND) of the starburst galaxy NGC 1068 using PdBI observations, there was clear evidence of differentiation where these two tracers peaked at different CND locations. The associated chemical analysis suggested that these two species can be used to distinguish and characterize different types of shocks.
However it remained unclear whether the HNCO traces slower shocks or simply warm, non-shocked gas with the limit in the spatial resolution (~1"-2") and number of transitions per species in the previous study. In this talk, we will share our most updated work with higher resolution (~0.5"-1") ALMA observations of more HNCO and

SiO transitions than in the previous study, with the hope for better constraining the origin of the shock(s), their location and gas temperatures in the CND of NGC 1068.

Tomoko Suzuki: "Dust, gas, and metal content in star-forming galaxies at z~3.3"

We conducted sub-mm observations with ALMA of star-forming galaxies at z~3.3, whose gas-phase metallicities have been previously measured. Single-band dust continuum emission tracing dust mass and the relation between the gas-phase metallicity and gas-to-dust mass ratio are used to estimate the gas masses. We find that the estimated gas mass fractions and gas depletion timescales show a wider spread at a fixed stellar mass than expected from the scaling relations. This result suggests a diversity of fundamental gas properties among galaxies on the star-forming main sequence. Comparing gas mass fraction and gas-phase metallicity between star-forming galaxies at z~3.3 and at lower redshifts, star-forming galaxies at z~3.3 appear to be more metal-poor than local galaxies with similar gas mass fractions. Using the gas regulator model, we find that this offset can be explained with the model tracks assuming higher mass-loading factors, which suggests that the mass-loading factor in outflows increases at earlier cosmic times.