Astrochemistry deals with the formation and destruction of matter in very different environments including the early universe, cold dense interstellar clouds, hot circumstellar regions, or planetary atmospheres. In this contribution I summarize our recent experimental activities in this field using radio frequency (rf) traps for confining ions and nanoparticles. Two electrode arrangements are shown in Figure 1. The cryogenic 22-pole is meanwhile a very common ion trap used for reaction dynamics and spectroscopy (see [1] and references therein), while the split ring electrode trap (SRET) has been developed for high temperature applications [2]. With closed cycle refrigerators, wall temperatures of 2.6 K have been achieved [3] while heating an $C_{60}^+$ ensemble with a CW CO$_2$ laser has resulted in temperatures above 2000 K [2].

Figure 1: Left: 22pole ion trap for studying the interaction between cold stored ions and a beam of neutrals. Right: Special quadrupole trap for monitoring hot particles via their black body radiation (BBR).

Many gas phase processes involving ions have been studied in rf traps, including bi- and termolecular reactions, radiative association, clustering, isomerization, and isotope fractionation. In this talk, I will mention a few examples: (i) Associative detachment in H$^+$ + H collisions measured in the temperature range between 10 and 135 K. (ii) So far unexplained is the experimental result that CH$^+$(v=0, J) does not react with H atoms for J = 0 at low temperatures, although the reaction is exothermic. (iii) In contrast to simple expectations, radiative association of H$^+$ colliding with H$_2$(J) is a factor of 2 slower for J = 0 than for J = 1. (iv) For reactions of N$^+$(3P$_{ja}$) with H$_2$(J), first state specific rate coefficients $k(J, j_a)$ have been derived [1].

There are many innovative activities based on the combination of lasers and ion traps [4]. A powerful new instrument used a cryogenic wire quadrupole and tunable IR lasers [3]. Very versatile is the new spectroscopy method called Laser Induced Inhibition of Complex Growth (LIICG) which has been developed in Basel [5] for studying candidates for the diffuse interstellar bands (e.g. $C_{60}^+$). This method has been applied first to N$_2^+$ ions and extended in Köln to CH$_5^+$ and H$_3^+$. As an example for measuring the stability of objects in a high temperature stationary state, the decay rates of a cloud of $C_{60}^+$ ions also will be mentioned [2].

References
[4] For more information and references see https://www.tu-chemnitz.de/physik/ION