# DNA Condensation Reactions in Microchannel Mixing Devices Observed by Microbeam-SAXS


Otten A.[1], Köster S.[1], Struth B.[2], Snigirev A.[2], Pfohl T.[1]

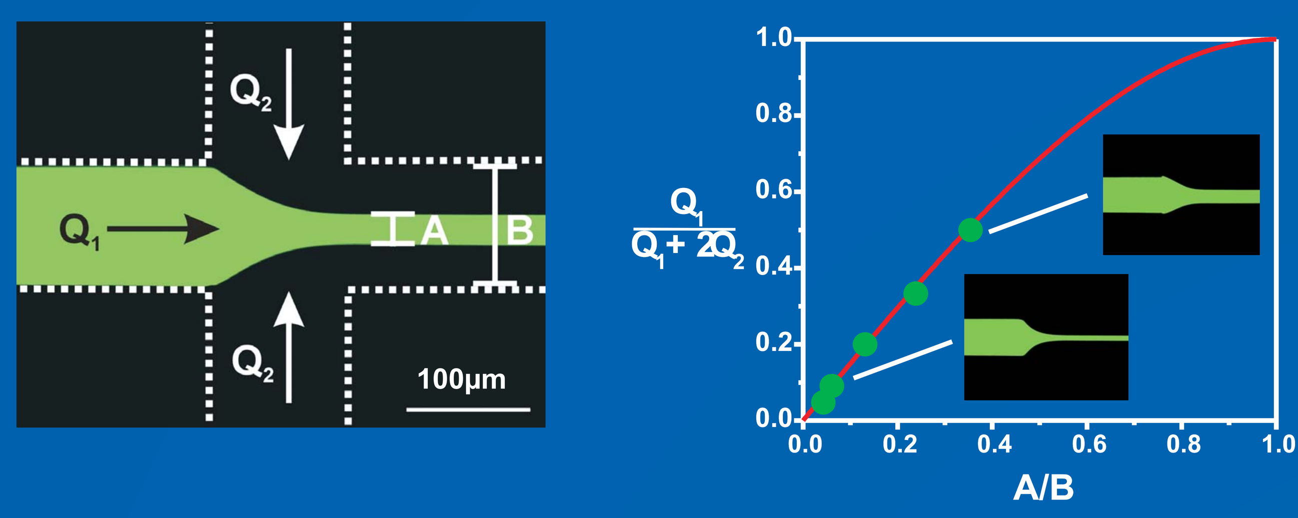
[1]Angewandte Physik, Universität Ulm, Albert-Einstein-Allee 11, D-89069 Ulm,

[2]ESRF, 6 Rue Jules Horowitz, 38043 Grenoble Cedex

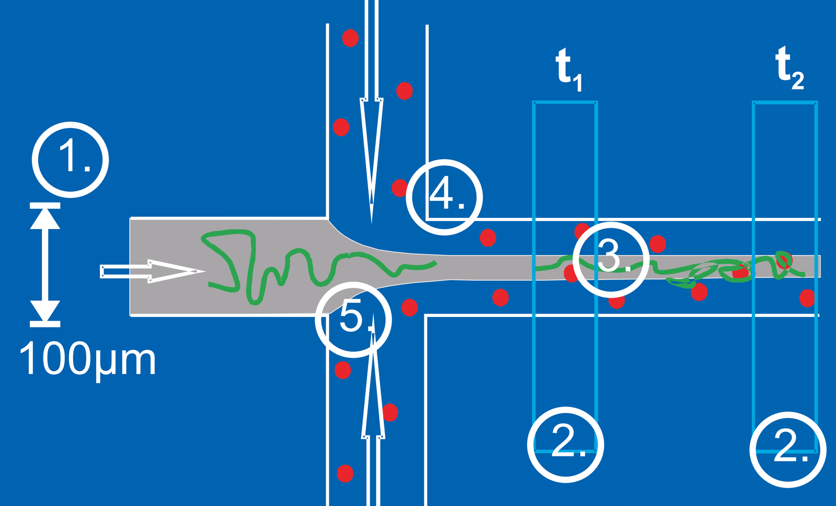

**Introduction**

**The application of microfluidic devices does not only allow us to analyze small volume fractions of e.g. biomaterial solutions but also gives access to faster observations and improved sample characterization. We use a microchannel device consisting of two crossed channels to examine the behavior of biomacromolecules in elongational flow as well as for studies on biomaterial aggregation. In our microfluidic focusing device a microjet flow is achieved by hydrodynamic focusing of a center stream by two symmetric side streams. The elongational flow and the biomaterial aggregation are studied by using microbeam-SAXS (small angle X-ray scattering) technique. To achieve a spatial resolution of 20µm, the x-ray beam is focused by compound refractive lenses. We present SAXS data on different columnar liquid crystalline phases of DNA condensed by polyamine dendrimers for different DNA/dendrimer concentrations. These phases can be observed under continuous flow and due to microfocusing intermediate regions of the phase transitions can be examined.**

## Hydrodynamic Focussing

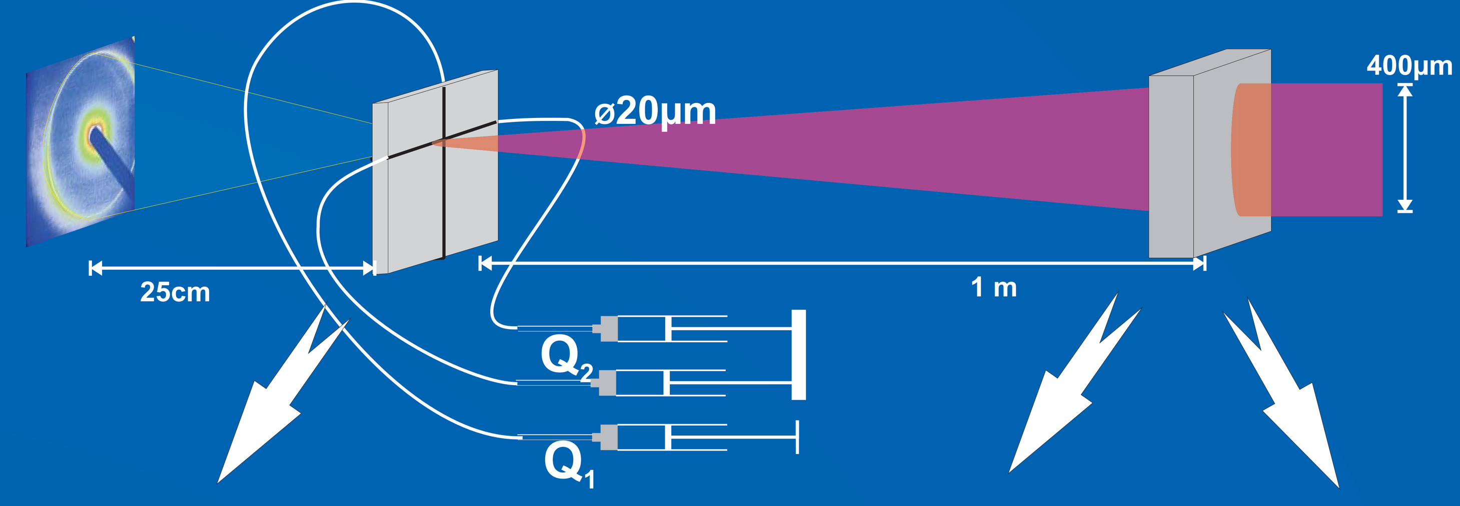


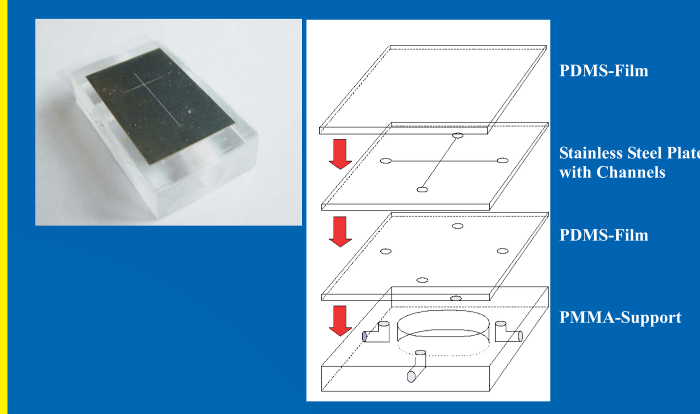

**Control of Stream Widths by Flow Rates $Q_1$ and $Q_2$**



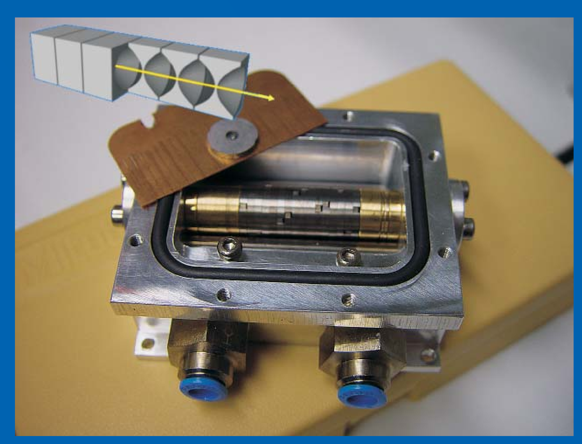

1. Low Material Consumption (pL/sec)
2. Time Resolution Along Stream Direction
3. Observation of Mixing Reactions
4. No Sample Damage due to High Beam Intensities
5. Orientation — Higher Correlation Length, Symmetry in LC-Phases
6. Cascadable Setup - Assembly Line

## ID10b Microbeam SAXS Setup

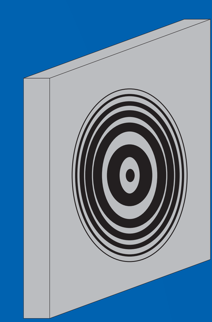


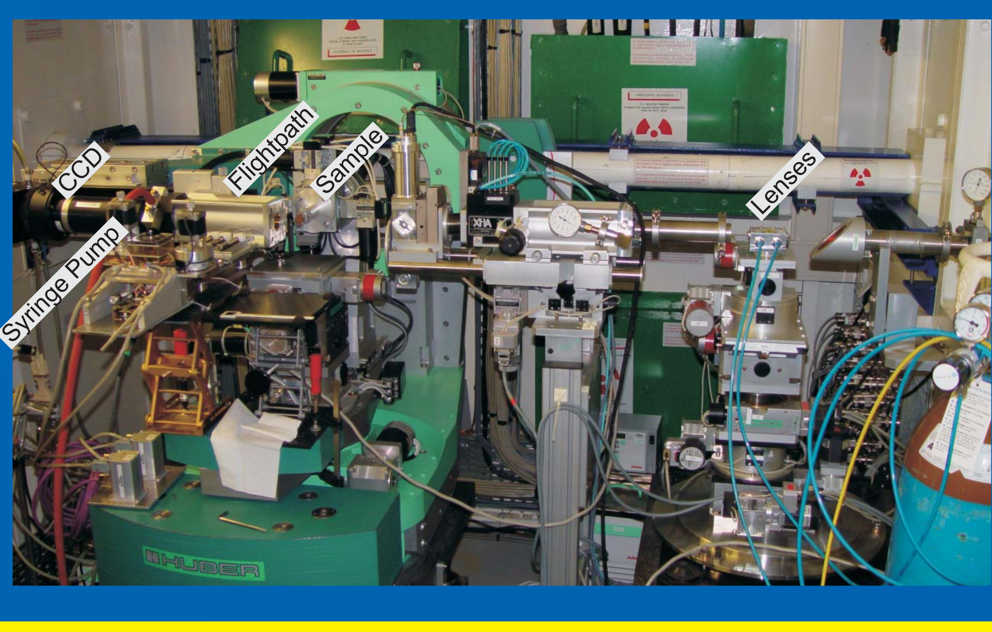

**In V2A Eroded Channels with PDMS Cover and PMMA Connector**



**Compound Refractive Lenses**

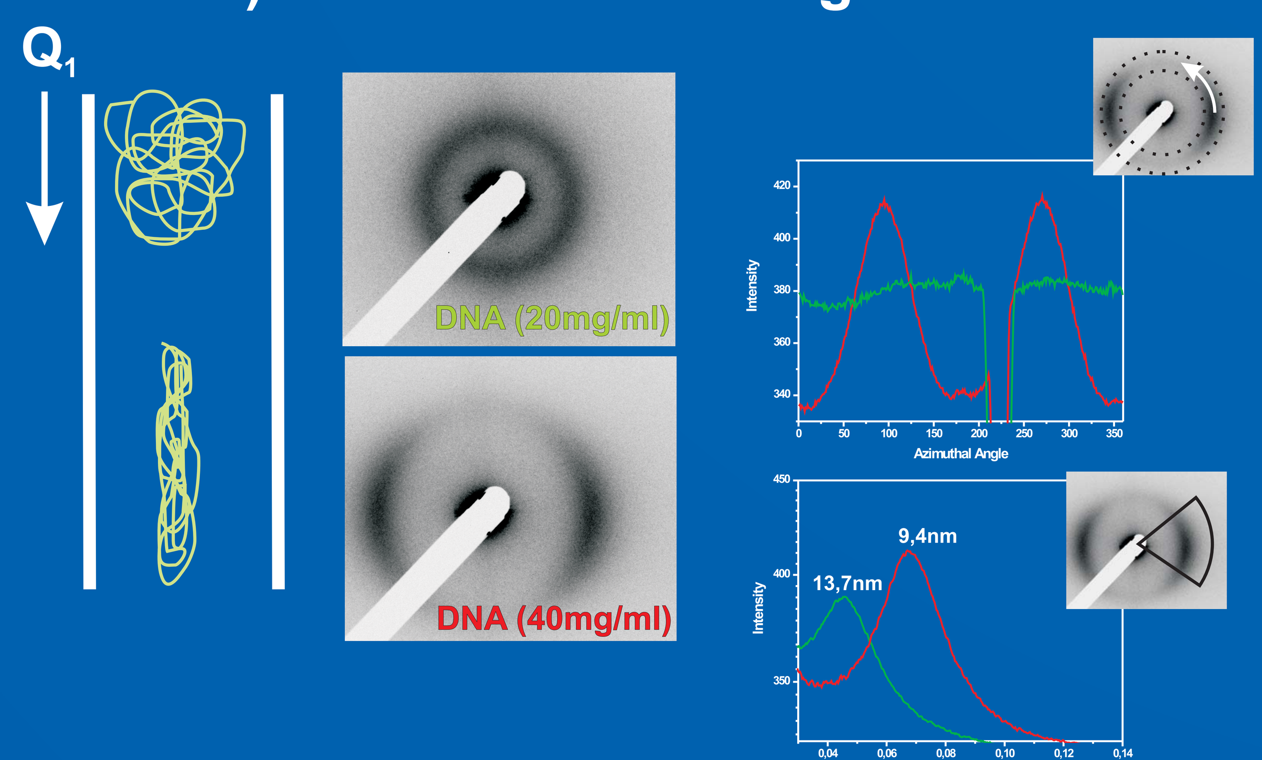


**Fresnel Zone Plate**

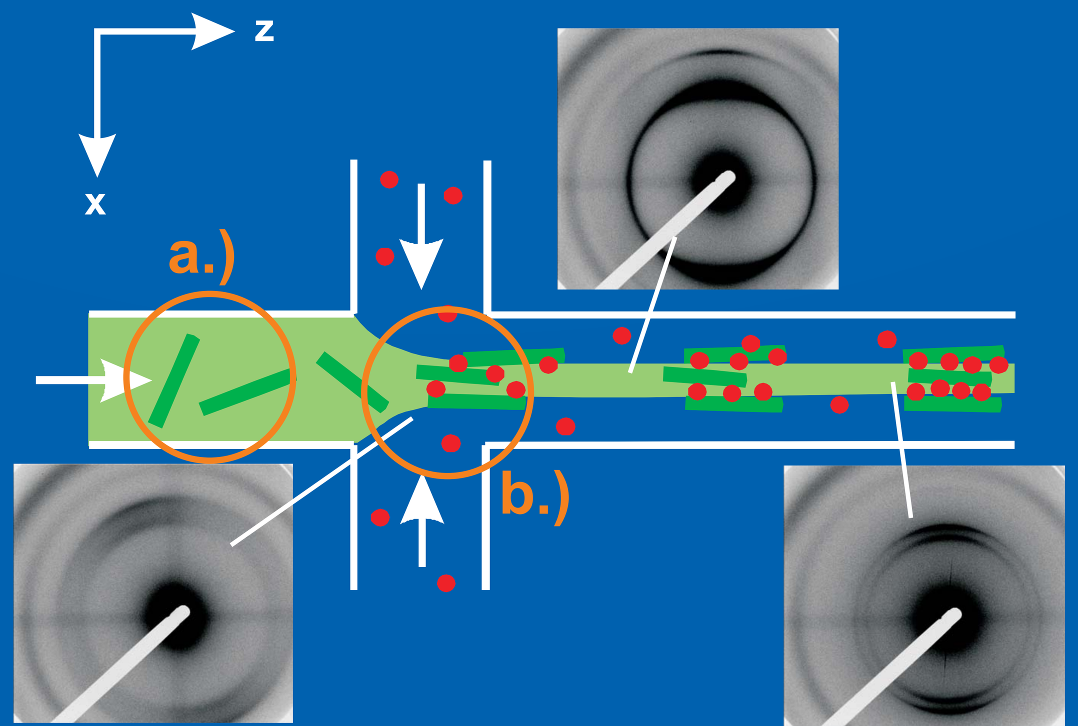



## DNA - Dendrimer G4 Complex Formation

### a.) Channel Flow Elongation

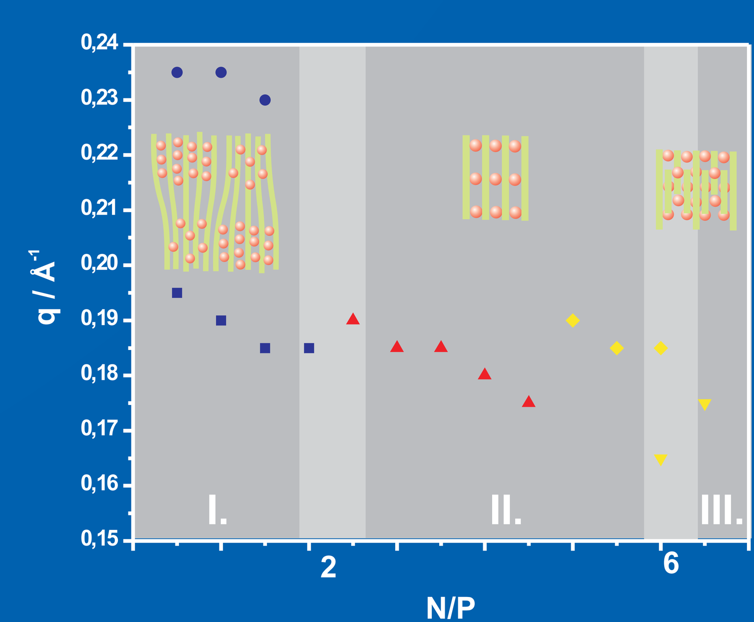



**DNA (∅=2nm) Complexation Reaction with Positively Charged Polyamine Dendrimers (∅=3,2nm) Observed by Microbeam SAXS Using Compound Refractive Lenses.**




**Observation of Multiple Supramolecular-Phases in one Experimental Run by Tuning the Reactants Concentration and the Flow Rates.**

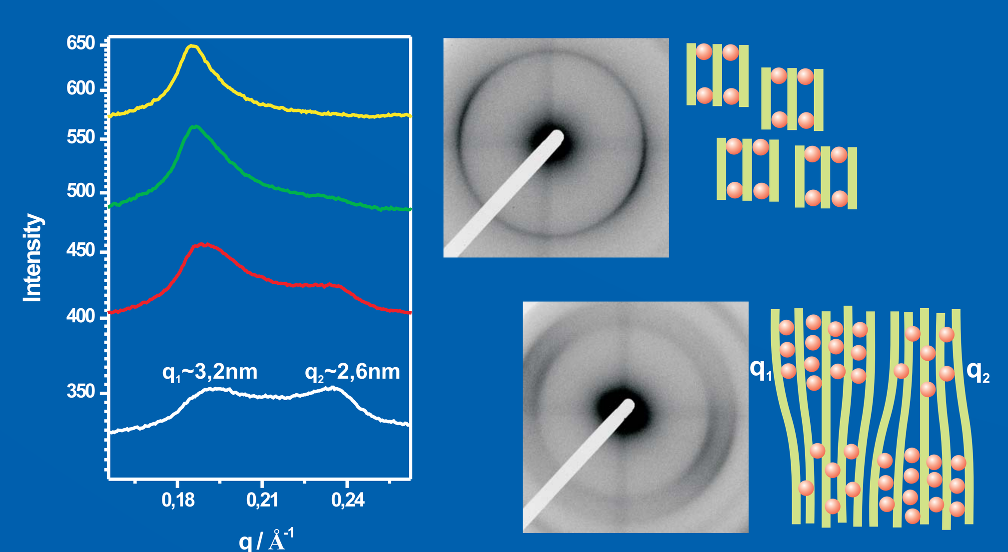
### Phase Diagram



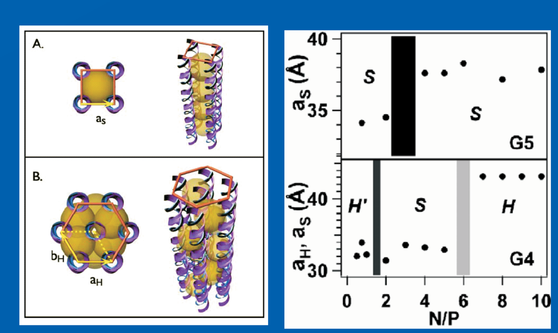

**N/P – Ratio Positive Charge (Amine/Dendrimer) to Negative Charge (Phosphate/DNA)**

**Structural Change from Hexagonal* (I.) to Square (II.) to Hexagonal (III.) Phase by Increasing Dendrimer Volume Fraction.**

### b.) Phase Transitions




**Transition from Hexagonal* to Square Lattice Along the Jet x-Direction from Center (White) to x=60µm (Yellow).**




Evans et al. PRL 2003