PAPER PRESENTATION-4

LETTER

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Fractal morphology, imaging and mass spectrometry of single aerosol particles in flight

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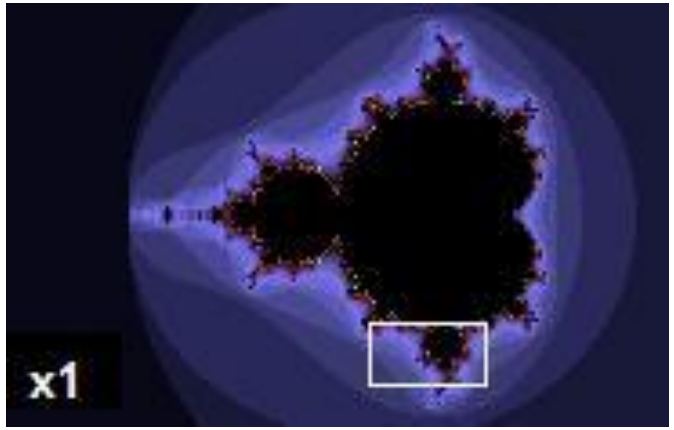
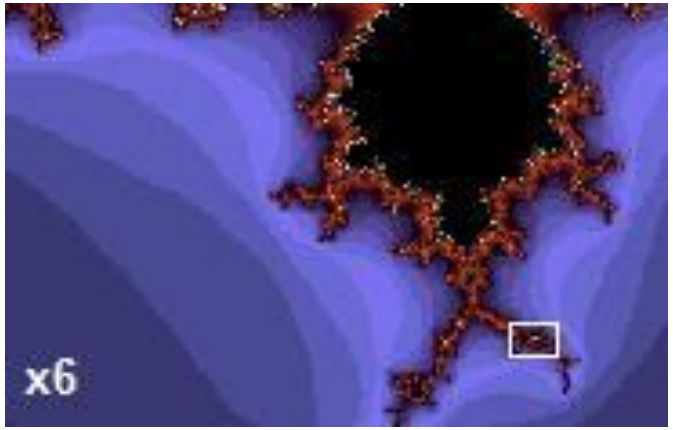
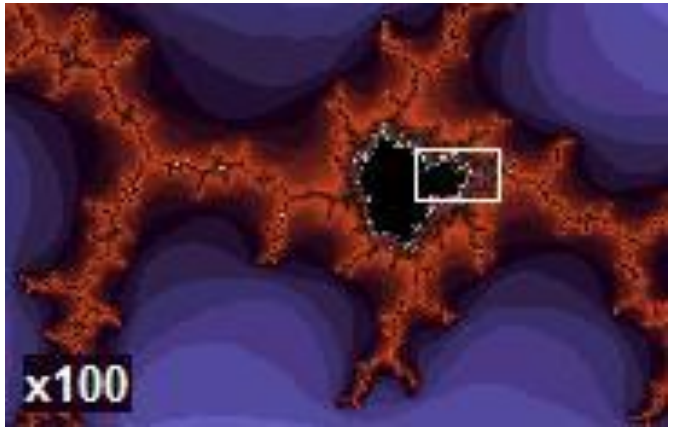
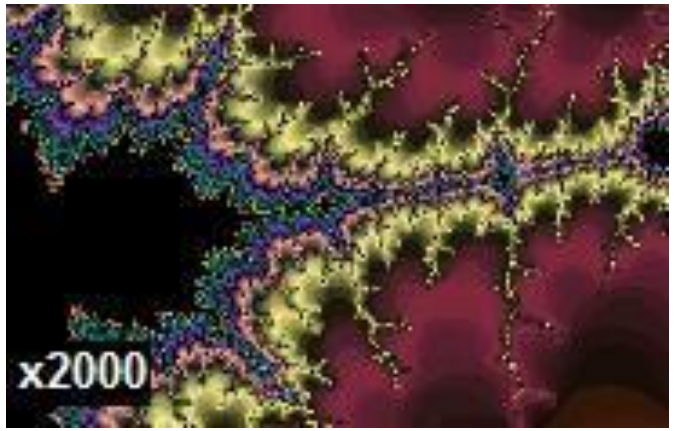
INTRODUCTION



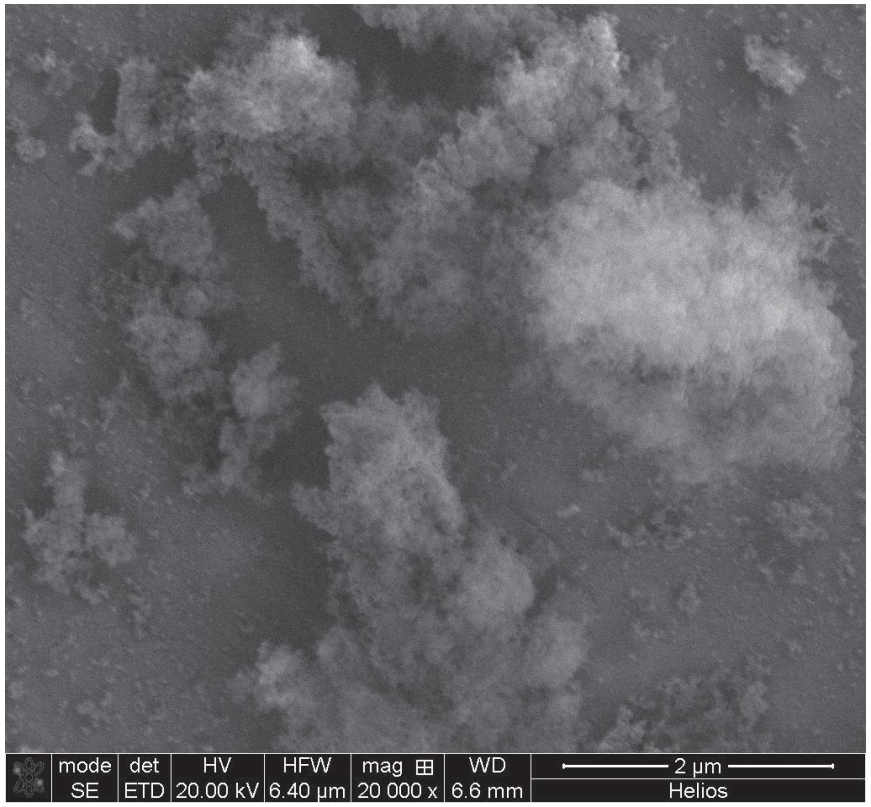






Mandelbrot set (God's finger print) Fractal

https://en.wikipedia.org/wiki/Fractal



SF-2: A scanning electron micrograph of dense soot aggregates similar to those injected into the FEL beam.

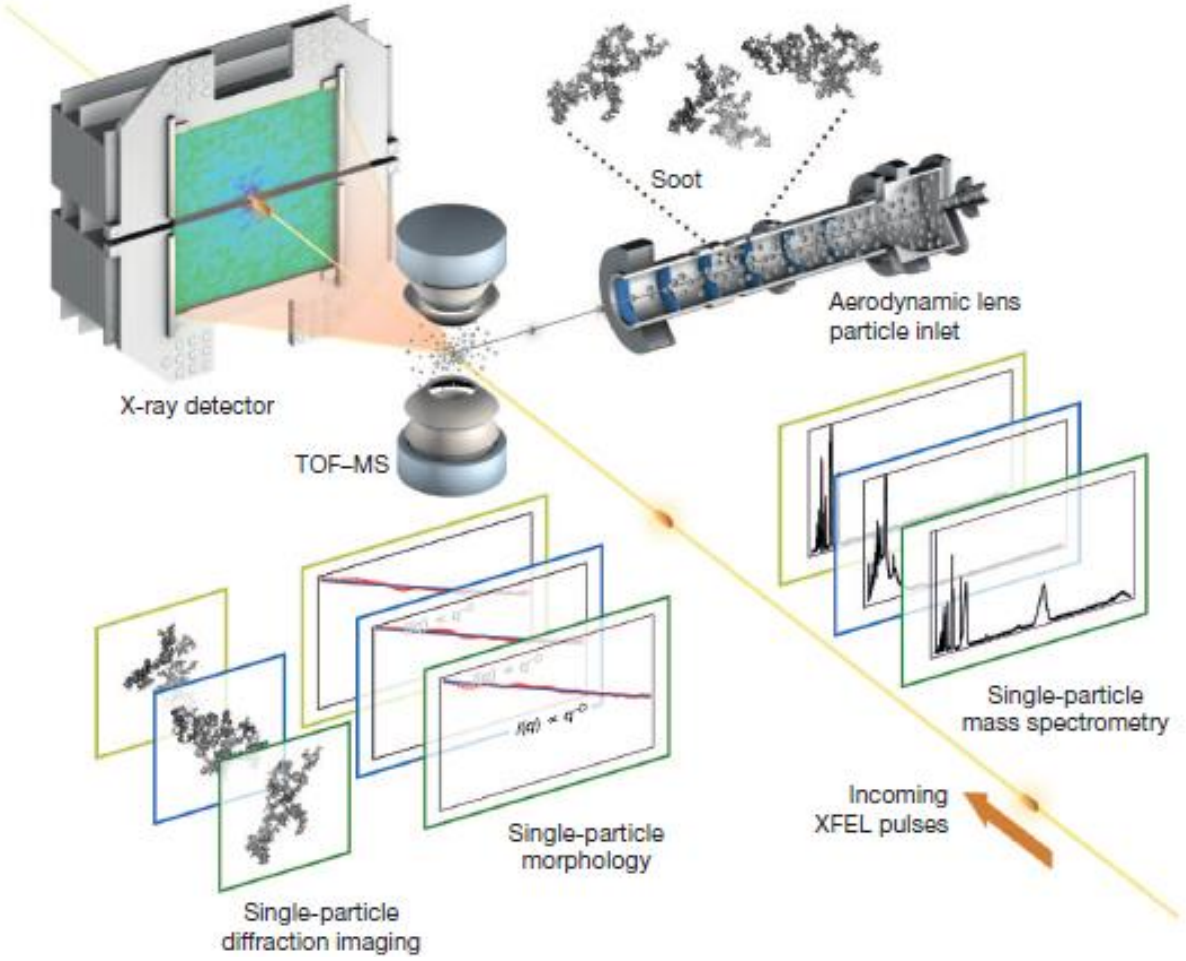
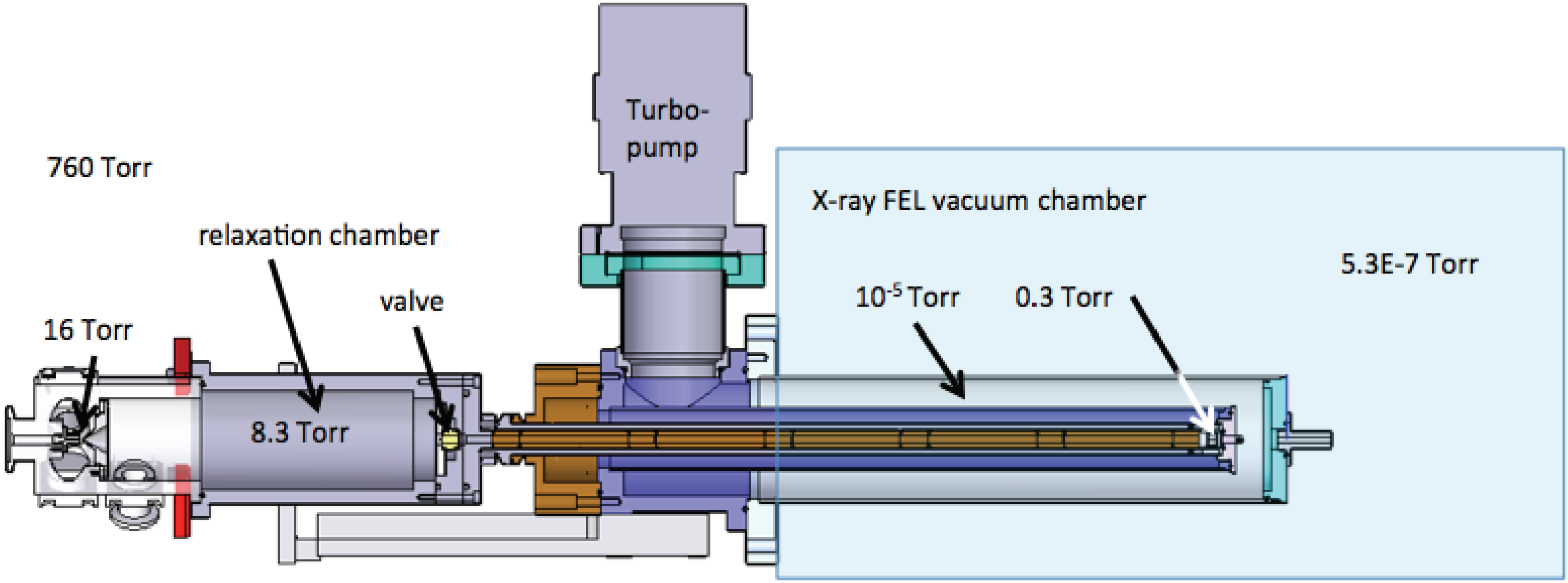


Figure-1 Schematic of concurrent imaging, morphology and spectroscopy of single soot particles in flight. Coherent XFEL pulses (orange) were made to intersect a particle stream, producing a diffraction pattern and ion fragments
whenever a pulse and a particle coincided. Diffraction patterns were measured
on a pnCCD (p–n-junction charge-coupled device) X-ray detector, and ion
fragments were captured by a time-of-flight mass spectrometer (TOF-MS),
both of which operated at the pulse repetition rate of 60 Hz.

EXPERIMENTAL SETUP



SF-1: A cross-section schematic of the aerodynamic lens stack. Aerosols were generated at the inlet (left) using a soot generator, a pneumatically-assisted sprayer, or a jet nebulizer containing a dry powder that is dispersed via agitation of the nebulizer and collisions with milling objects and then transferred to the lens stack aerosol inlet via a stream of 2 l/min compressed gas. Mixed aerosols such as soot+NaCl aggregates were obtained by directing two separate aerosol streams into a relaxation chamber located immediately before the aerosol inlet of the lens stack as shown in this Figure. The particle beam exits at the right into the vacuum chamber where it intersects with the FEL pulses.

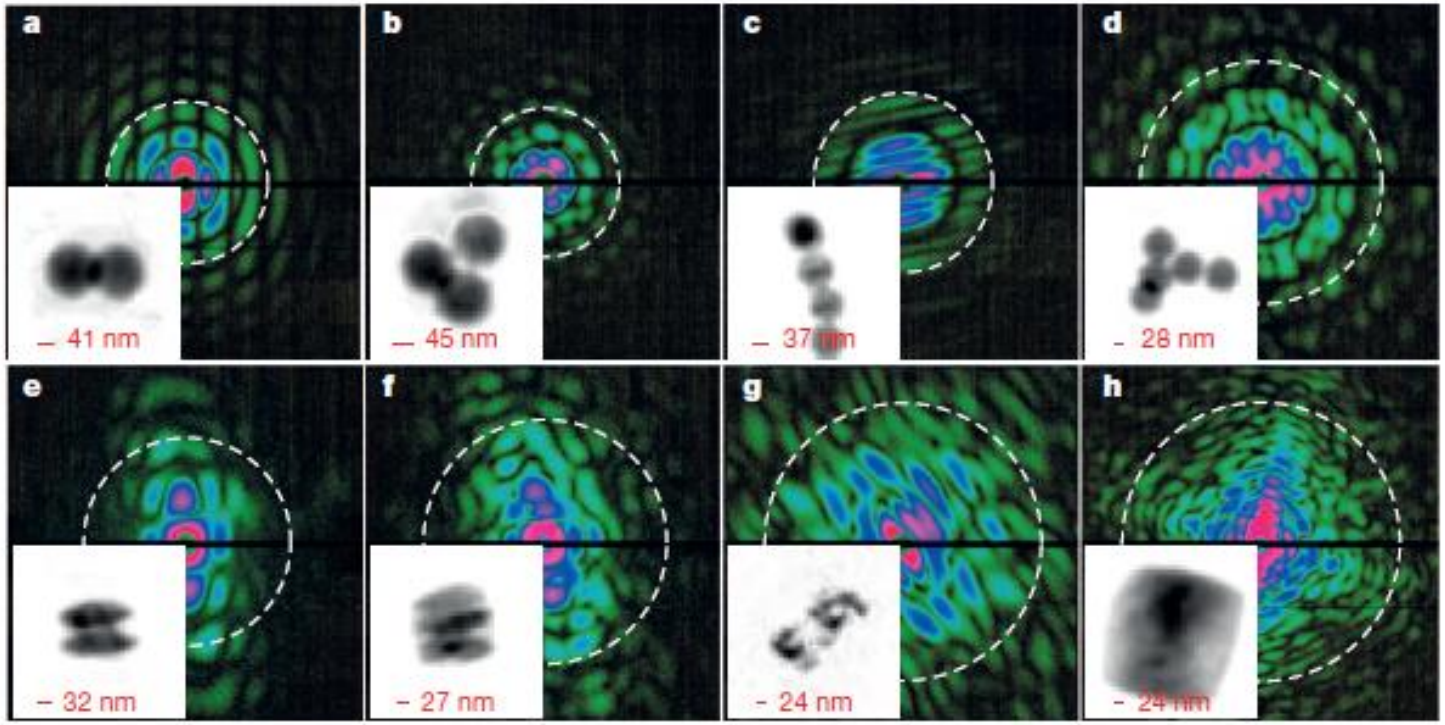


Figure 2: Diffraction patterns of self-assemblies of particles in flight, and reconstructions of their electron densities. a–d, Polystyrene spheres with radii of 70nm (a, b) and 44nm (c, d). e, f, Ellipsoidal nanoparticles. g, A spark generated soot particle. h, A salt–soot mixture. Electron density maps were averaged from ten independent, randomly initialized phase-retrieval reconstructions. Red scale bars in the insets also correspond to the full-period resolutions of the respective reconstructions (white circles in the diffraction patterns). The wavelength of incident radiation was 1.0 nm.

RESULTS

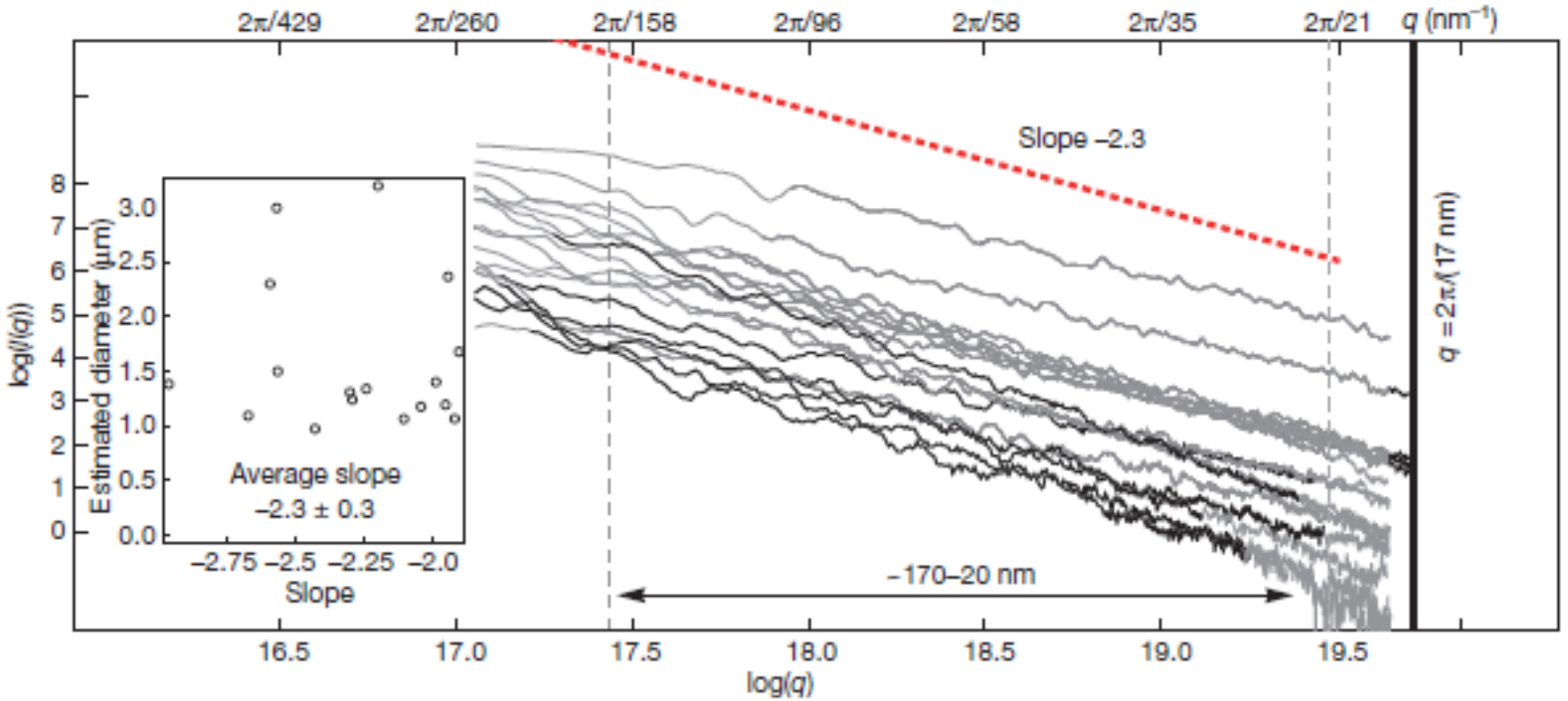


Figure 3: Fractal morphology of micrometre-sized soot aggregates. We show the unnormalized I(q) of 17 of our largest spark-generated soot particles. The slopes of distinctly linear regions in the log–log plot of I(q) (darkened segments) is the negative of each particle's fractal dimension, showing a range of dilation symmetry (170–20 nm) common to these particles. The inset shows these slopes, plotted against the respective particle sizes.

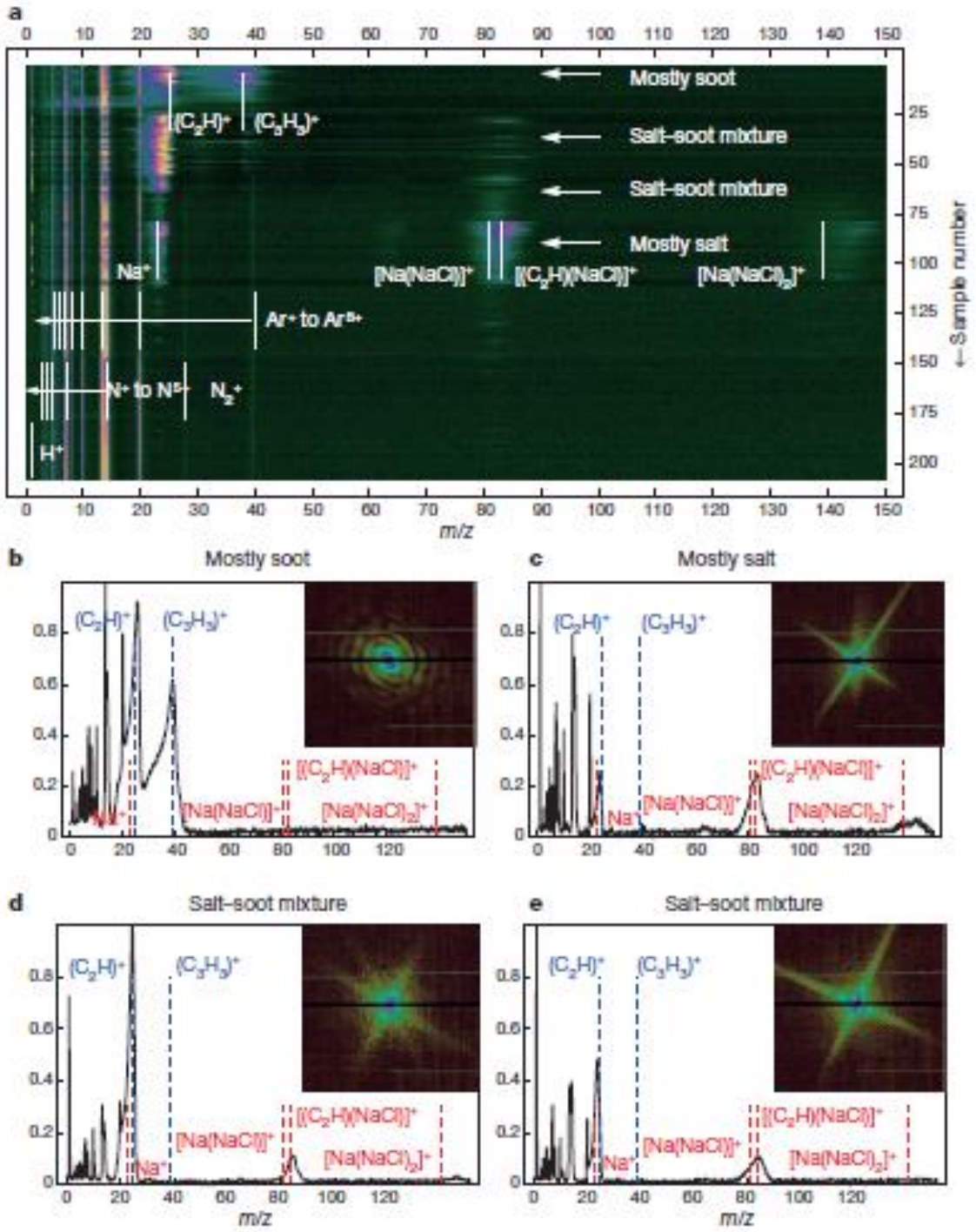


Figure-4: Time-of-flight mass spectrometry concurrent with diffraction imaging. a, TOF-MS spectra, with labels showing the m/z values most compatible with the composition of our samples. Each of the 208 rows represents a TOF-MS spectrum collected simultaneously with the diffraction pattern from single aggregates. The argon peaks come from the argon carrier gas for the soot, and are used to calibrate the spectra. The nitrogen peaks are from nitrogen gas used to nebulize salt from solution. b–e, Four typical spectra corresponding to rows marked with arrows in a, showing various admixtures of soot and salt in an aggregate. Their respective diffraction patterns are inset. Signatures of salt (diffraction streaks from rounded facets of salt agglomerates; also see Fig. 2h) and soot in these patterns match those in the corresponding TOF-MS spectra.

CONCLUSIONS

Particulate matter was imaged using diffraction

These particles' chemical nature was analysed using a TOF-MS

Extent of internal dilation symmetry of individual soot particles subject to non-equilibrium aggregation, and the surprisingly large variability in their fractal dimensions.

THANK YOU