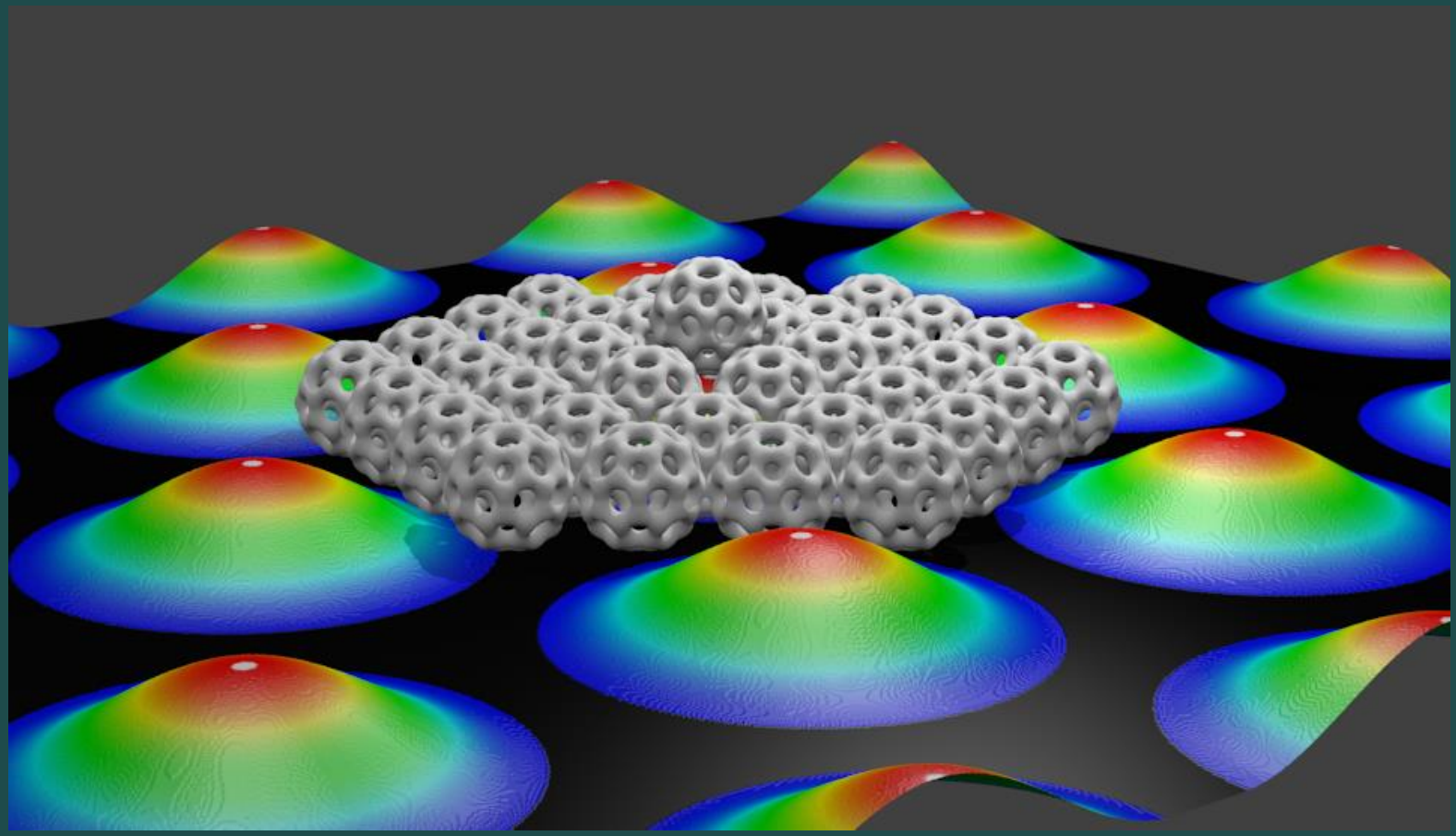
Formation of Magic-number C_{60}-clusters on a Surface Mediated by Atomic Scale Moiré Magnifiers



J. P. Chou, C. M. Wei, M. Y. Lai, Y.uh-Lin Wang (王玉麟)
IAMS, Academia Sinica, Taiwan; A. V. Zotov, and A. A. Saranin
Institute of Automation and Control Processes, Vladivostok, Russia

at Physics Dept. NTHU, May 16, 2013

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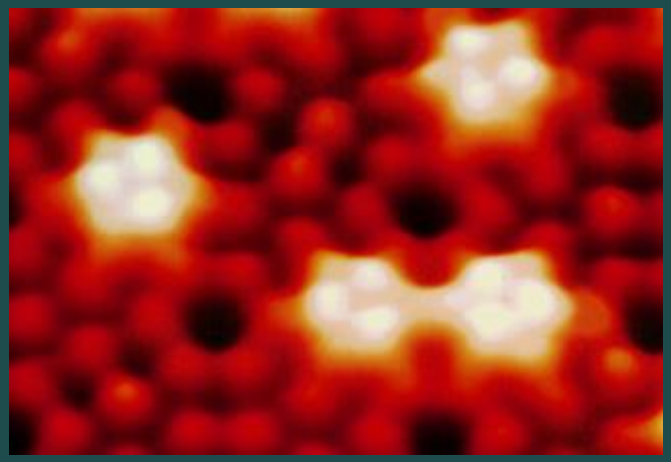
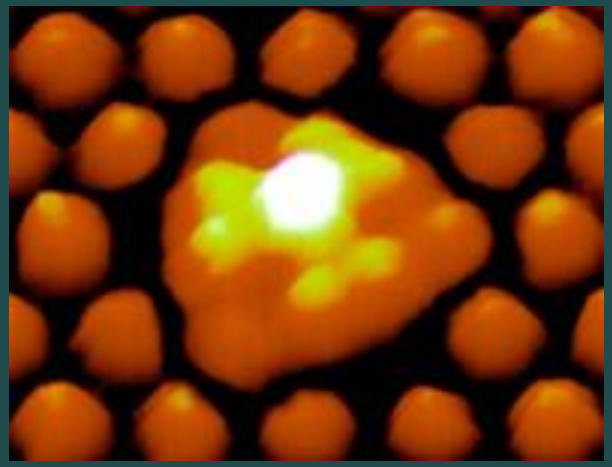
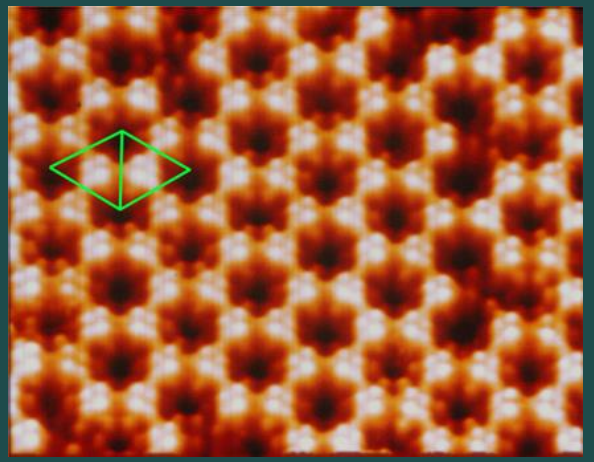
Formation of magic-number C_{60}-clusters on a surface mediated by atomic scale moiré magnifiers



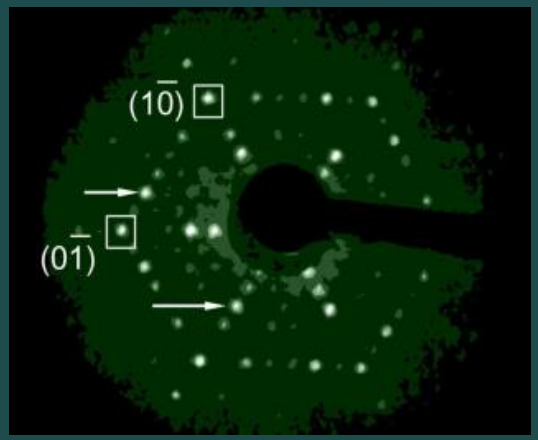
PRB 2001



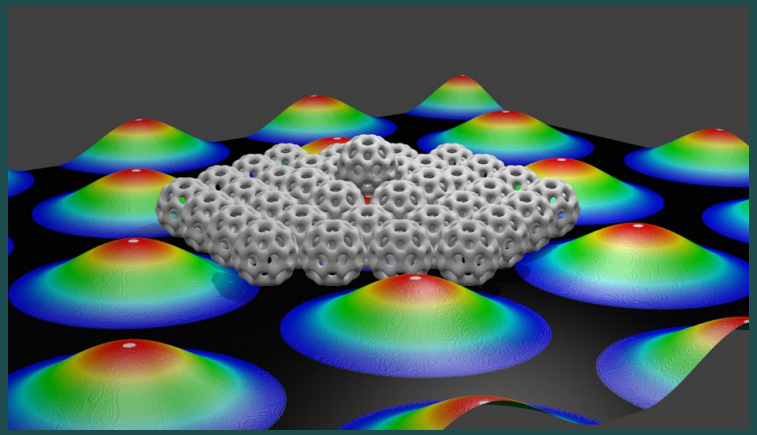
PRL 1998, PRB 1999



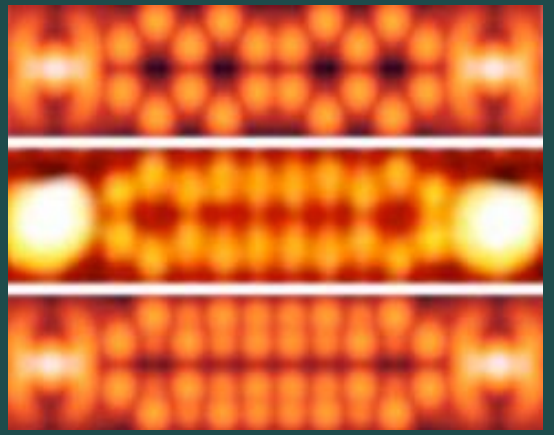
PRB 2001



PRL 2004



Nat. Comm. 2013



PRL 2011

Yuh-Lin Wang, M. Y. Lai, H. H. Chang, J. P. Chou, C. M. Wei
IAMS, Academia Sinica, Taiwan; A. V. Zotov, and A. A. Saranin
Institute of Automation and Control Processes, Vladivostok, Russia

at Physics Dept. NTHU, May 16, 2013

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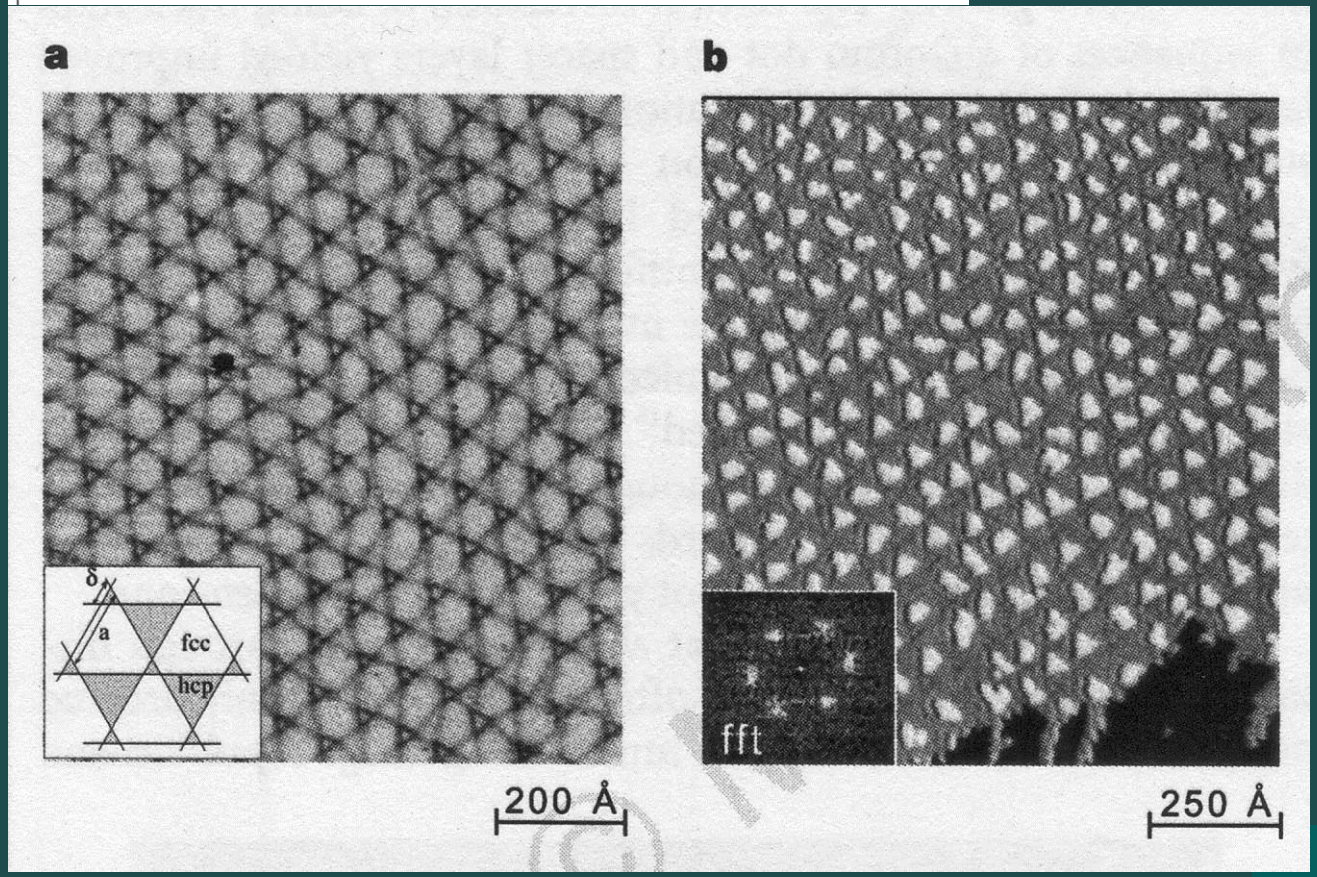
Self-organized growth of nanostructure arrays on strain-relief patterns

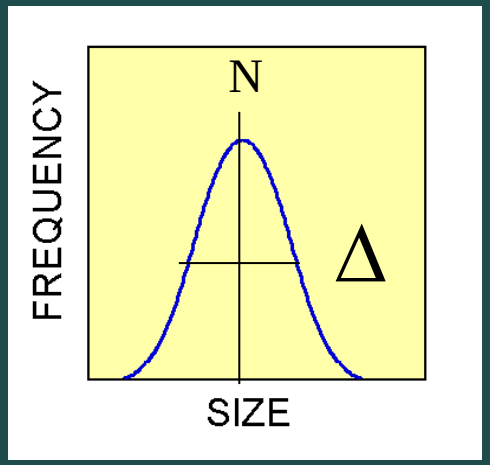
Harald Brune, Marcella Giovannini, Karsten Bromann & Klaus Kern

Institut de Physique Expérimentale, EPF Lausanne, CH-1015 Lausanne, Switzerland

Dislocation networks on 2-ML Ag/Pt(111) substrate surface.

Ag-nanoclusters formed by depositing 0.1 ML of Ag at 110K.





$$\Delta \sim (N)^{1/2}$$

Nature 394 (1998) 451

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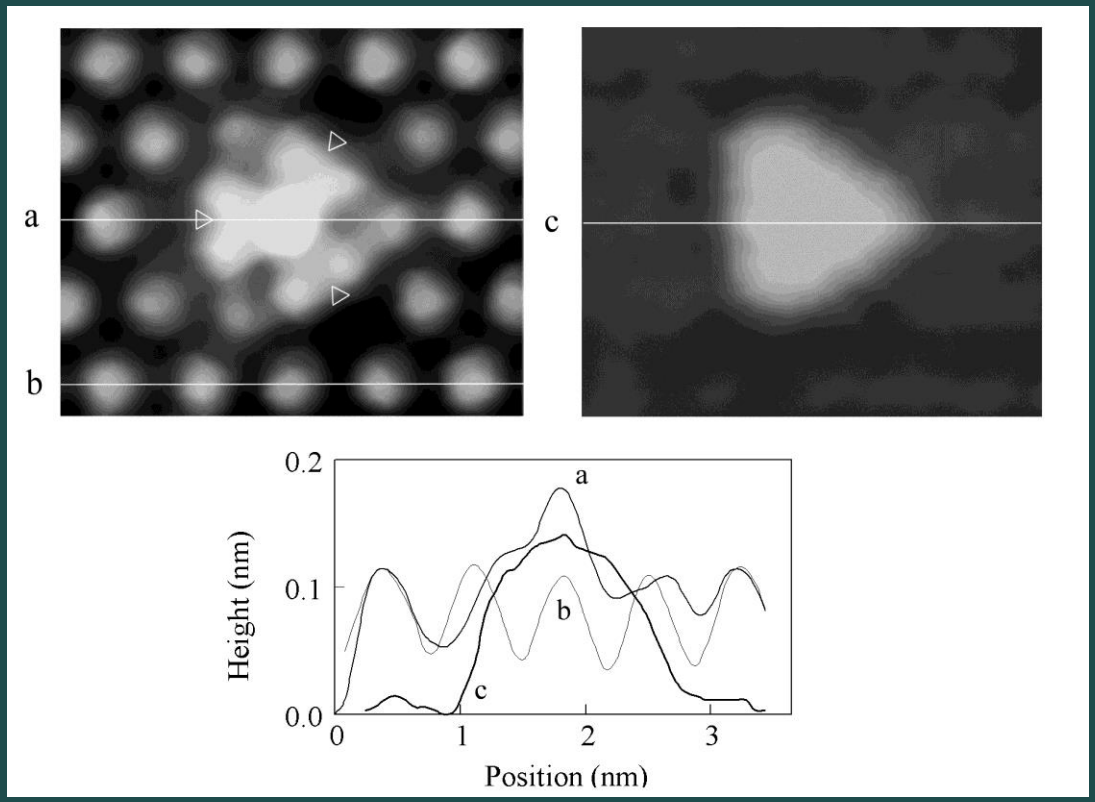
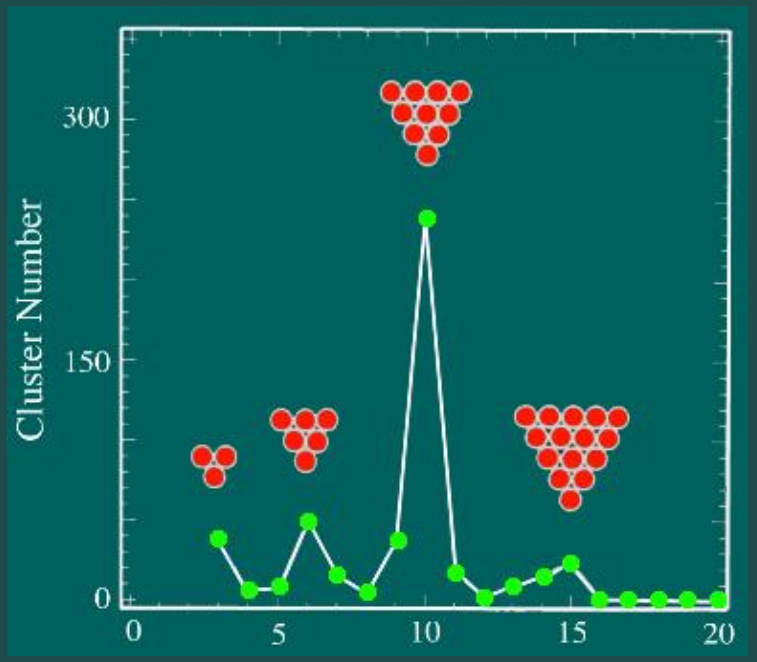
The first observation of surface magic-number cluster (SMC)

empty state STM image filled state STM image





M. Y. Lai & Y. L. Wang, Phys. Rev. Lett. **81** (1998) 164

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Electronic Shell Closure (citation=1432)

VOLUME 52, NUMBER 24 PHYSICAL REVIEW LETTERS 11 JUNE 1984

Electronic Shell Structure and Abundances of Sodium Clusters

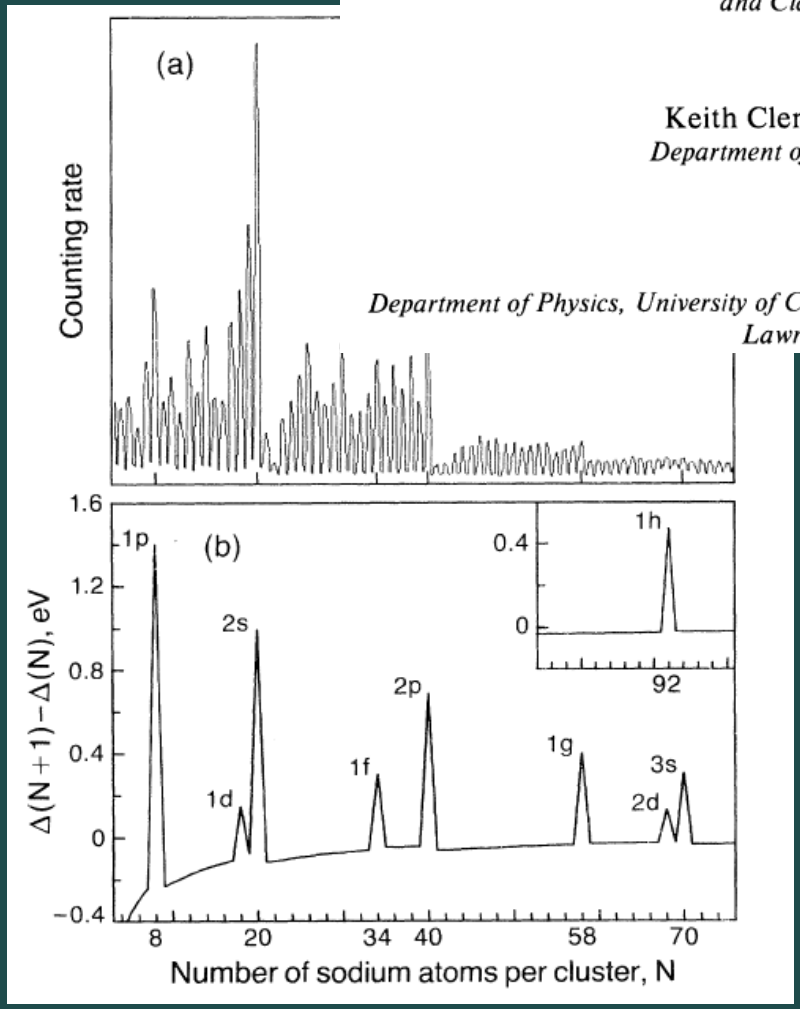
W. D. Knight
Department of Physics, University of California, Berkeley, California 94720, [a]
and Clarendon Laboratory, Oxford OX1 3PU, United Kingdom

and

Keith Clemenger, Walt A. de Heer, and Winston A. Saunders
Department of Physics, University of California, Berkeley, California 94720

and

M. Y. Chou and Marvin L. Cohen
Department of Physics, University of California, Berkeley, California 94720, and Materials and Molecular Research Division, Lawrence Berkeley Laboratory, Berkeley, California 94720



$$U(r) = -\frac{U_0}{\exp[(r - r_0)/\epsilon] + 1}$$

Mei Yin Chou (周美吟)
Director
IAMS (2011~)

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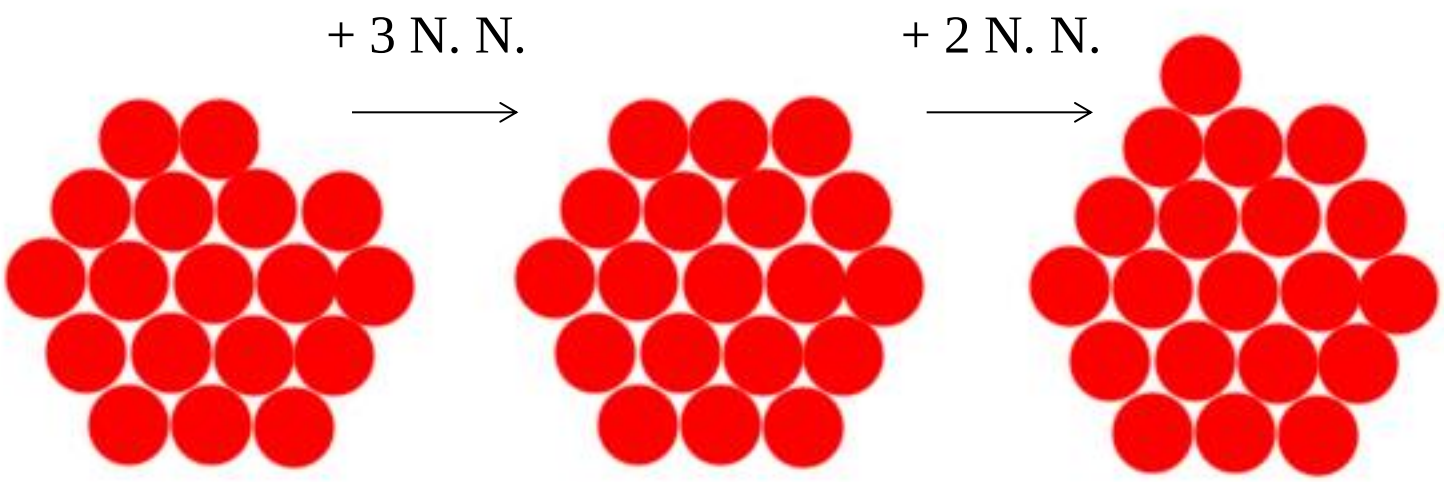
Geometric Shell Closure



Geometrically Closed

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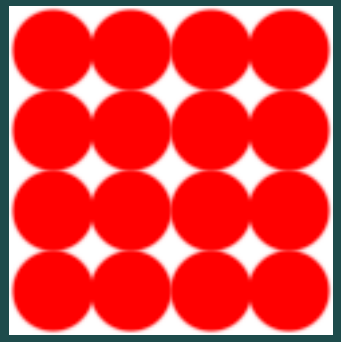
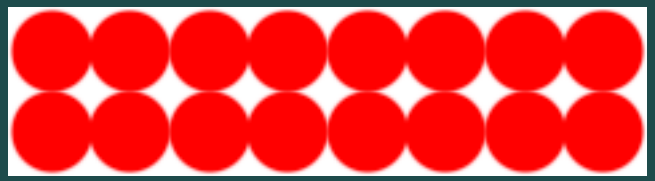
Geometric Shell Closure

NNN = 24



NNN = 16x(4/2) - (12x1- 4x1)
= 24

NNN = 22



NNN = 16x(4/2) - (16x1 - 4x1)
= 22

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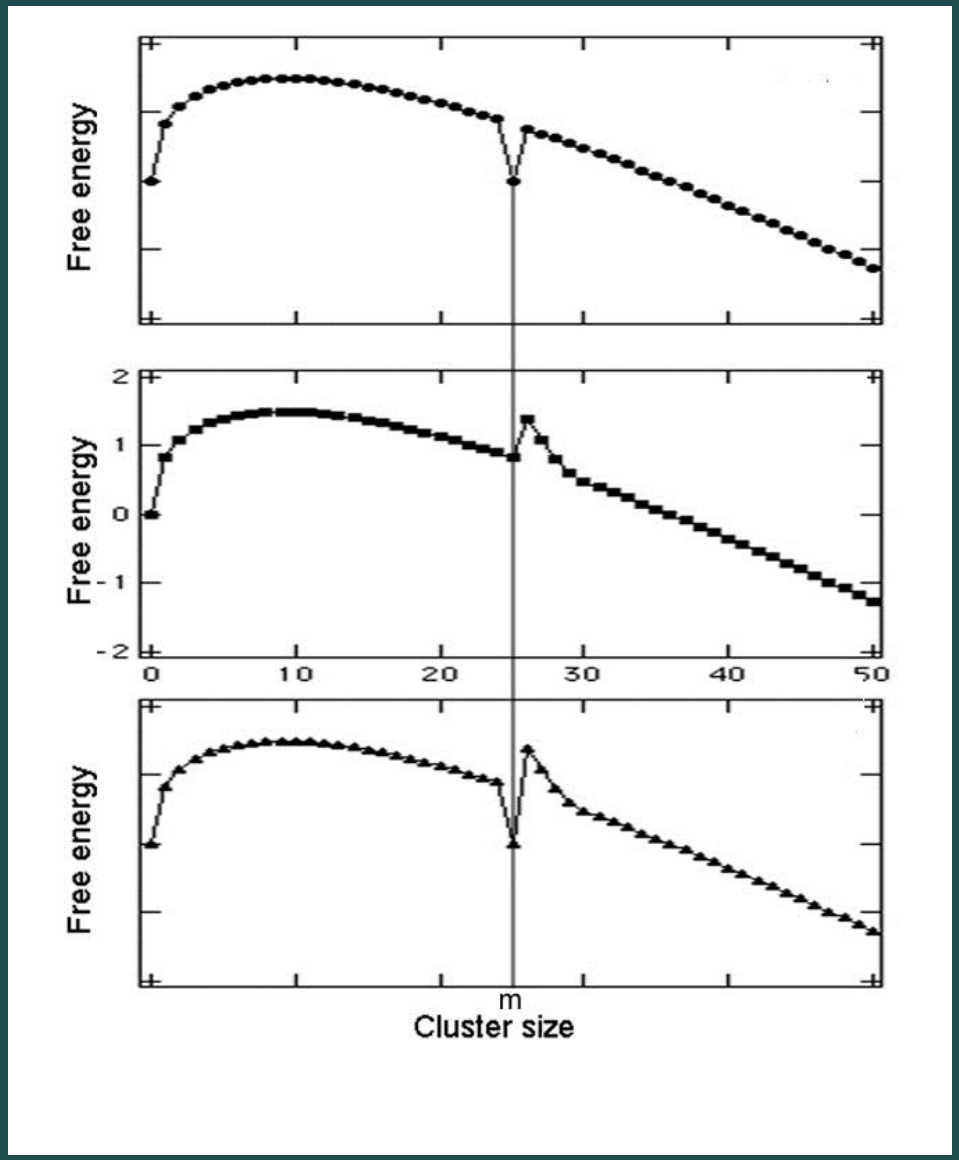
Free energy of clusters formation



in 3d

$\Delta G = -ar^3 + br^2$

$-a'N + b'N^{2/3}$

in 2d

$\Delta G = -ar^2 + br$

$-a'N + b'N^{1/2}$

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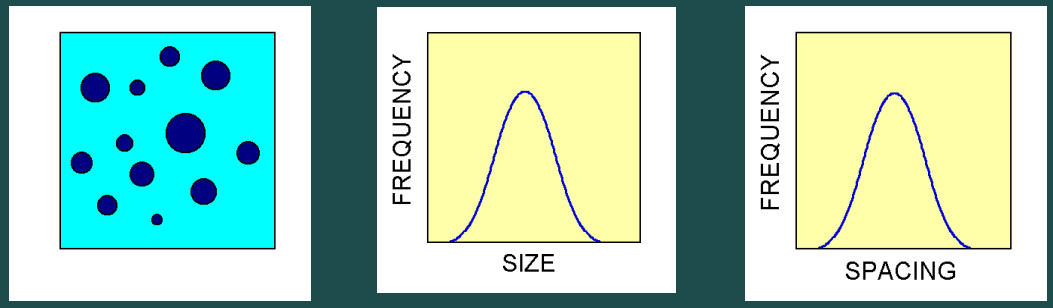
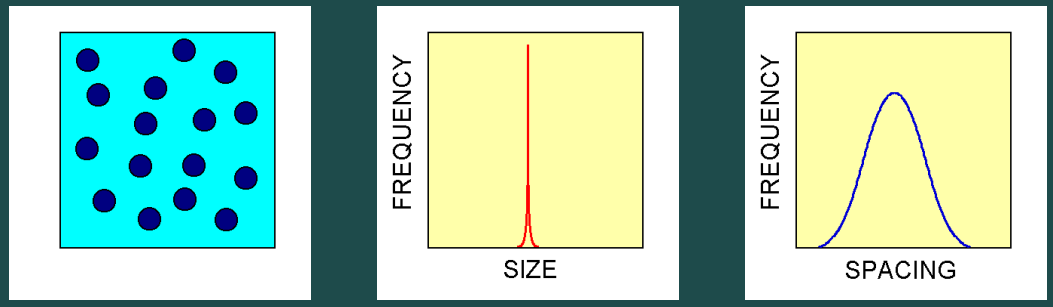
Nanocluster arrays

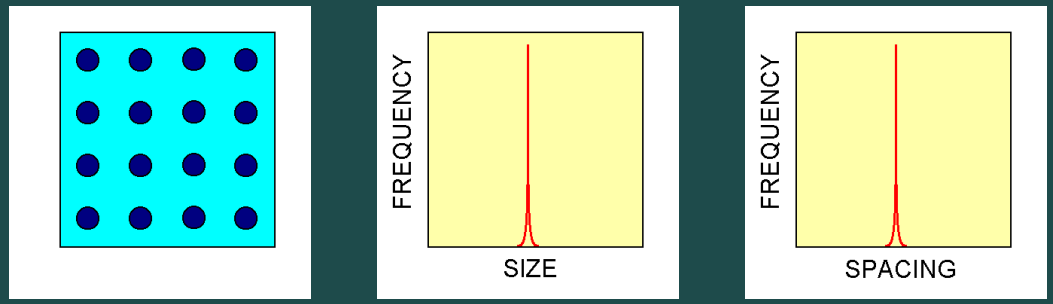
Random cluster array



Random array of identical (magic) clusters



Ordered array of identical (magic) clusters



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Self-Assembly of C_{60} Islands on the Si(111)-$\sqrt{3}\times\sqrt{3}$-(Au,In)

Experimental Observations

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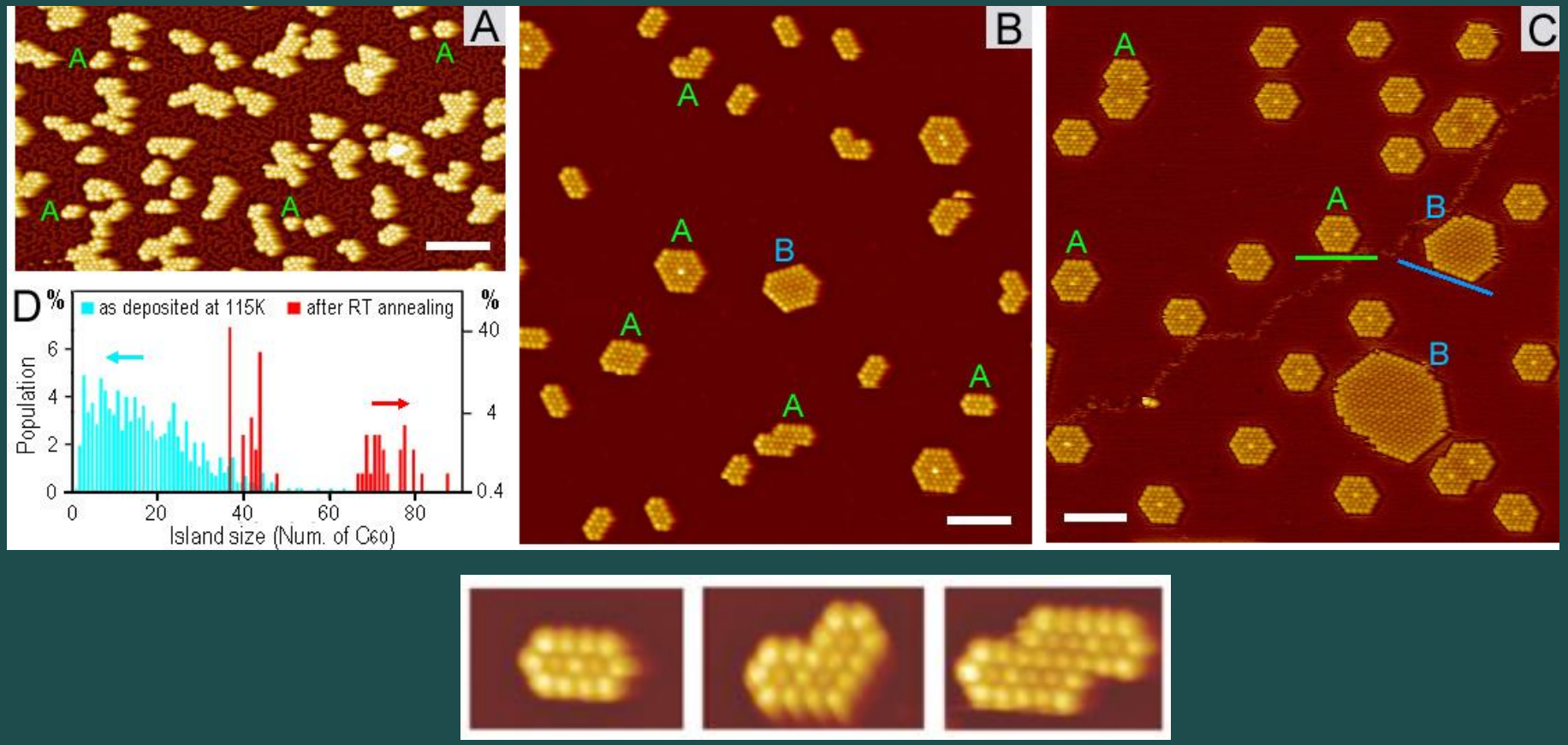
Upon slow heating to RT, random C_{60} islands coarsen into the islands with regular shape



$100 \times 100\ nm^2$ (V_{tip}=-1.9 V I_t=200 pA)

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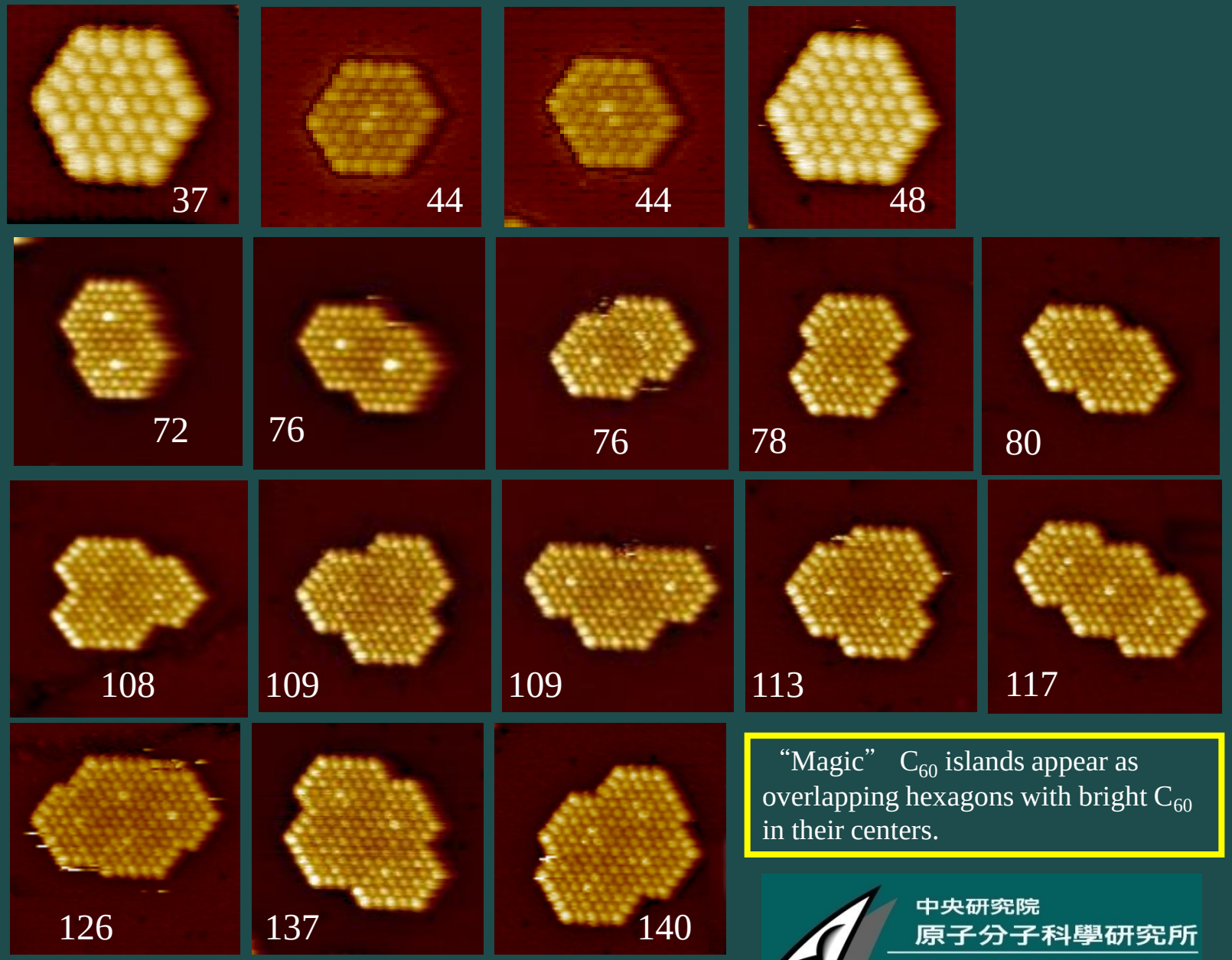
C_{60} on Si(111)-√3×√3-(Au,In): "magic" C_{60} islands



"Magic" C_{60} islands appear as overlapping hexagons with bright C_{60} in their centers.

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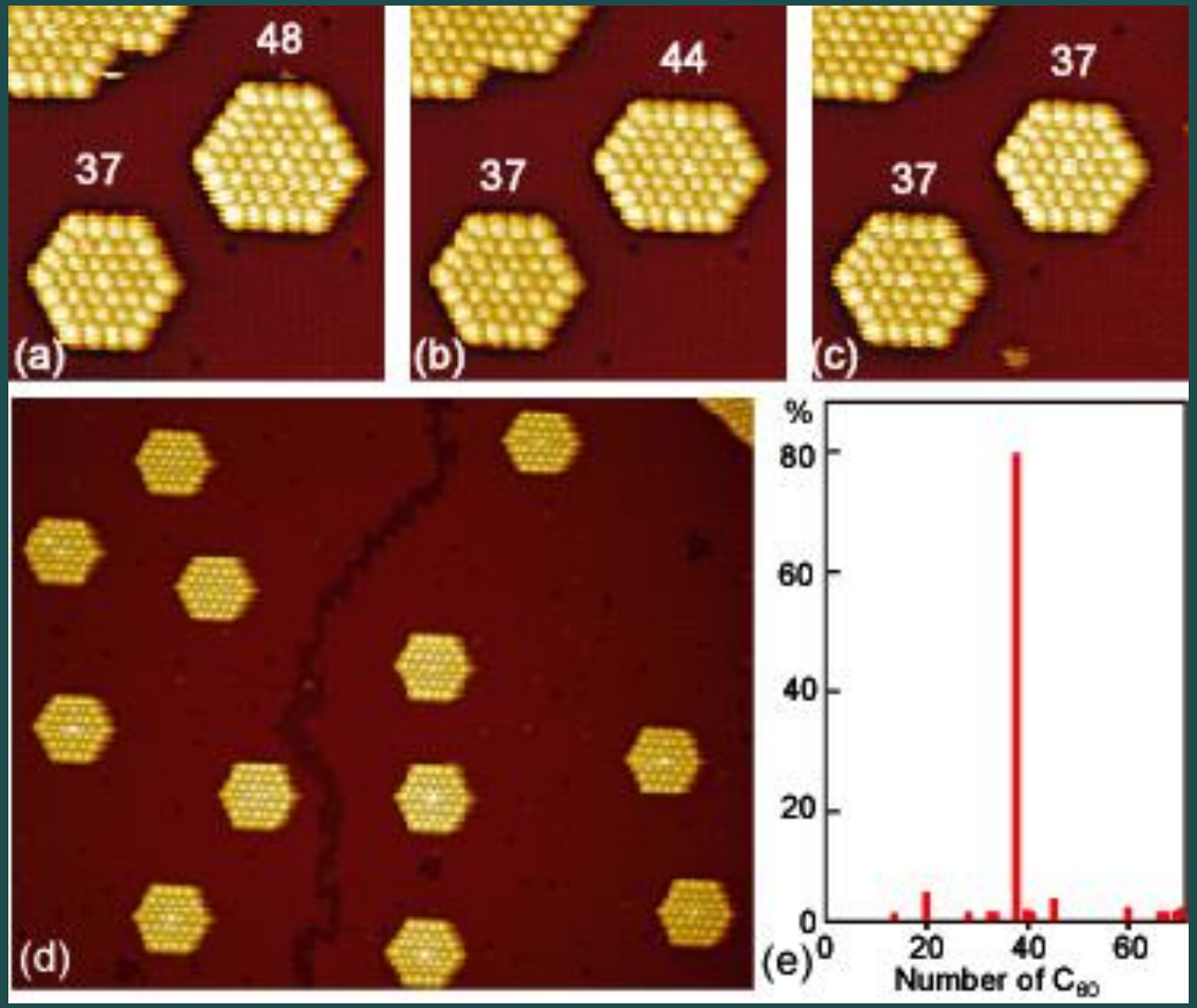
Prolong RT annealing leads to the formation of “magic” 37-mer islands



37mer is the most stable 1st-generation C_{60} island.

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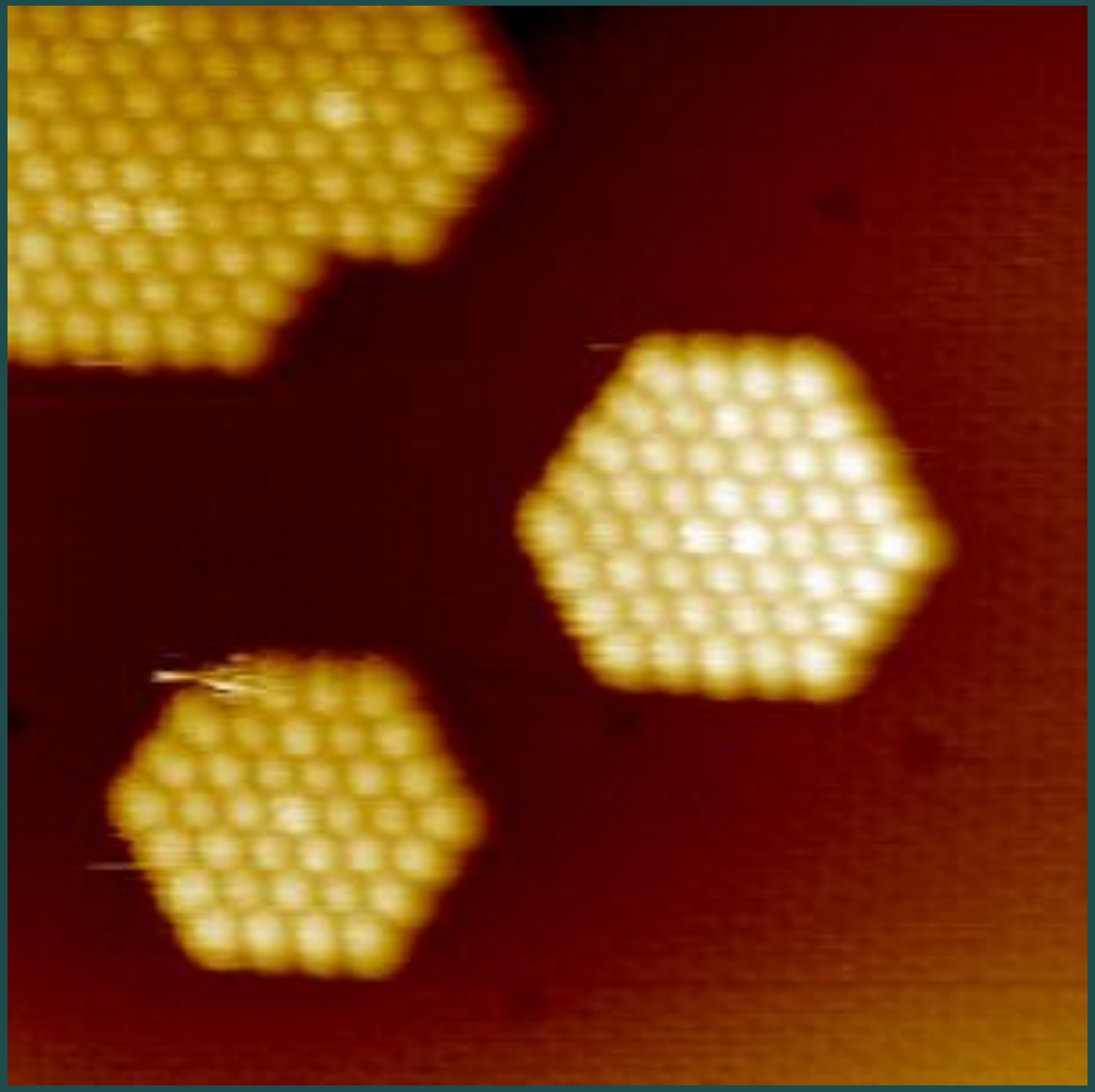
STM movie showing a magic 37-mer and a 48-mer turning into a 37-mer



Snapshots illustrating the dynamic process of C_{60} island ripening towards the more stable forms. Observations are taken at room temperature and C_{60} flux is switched off.

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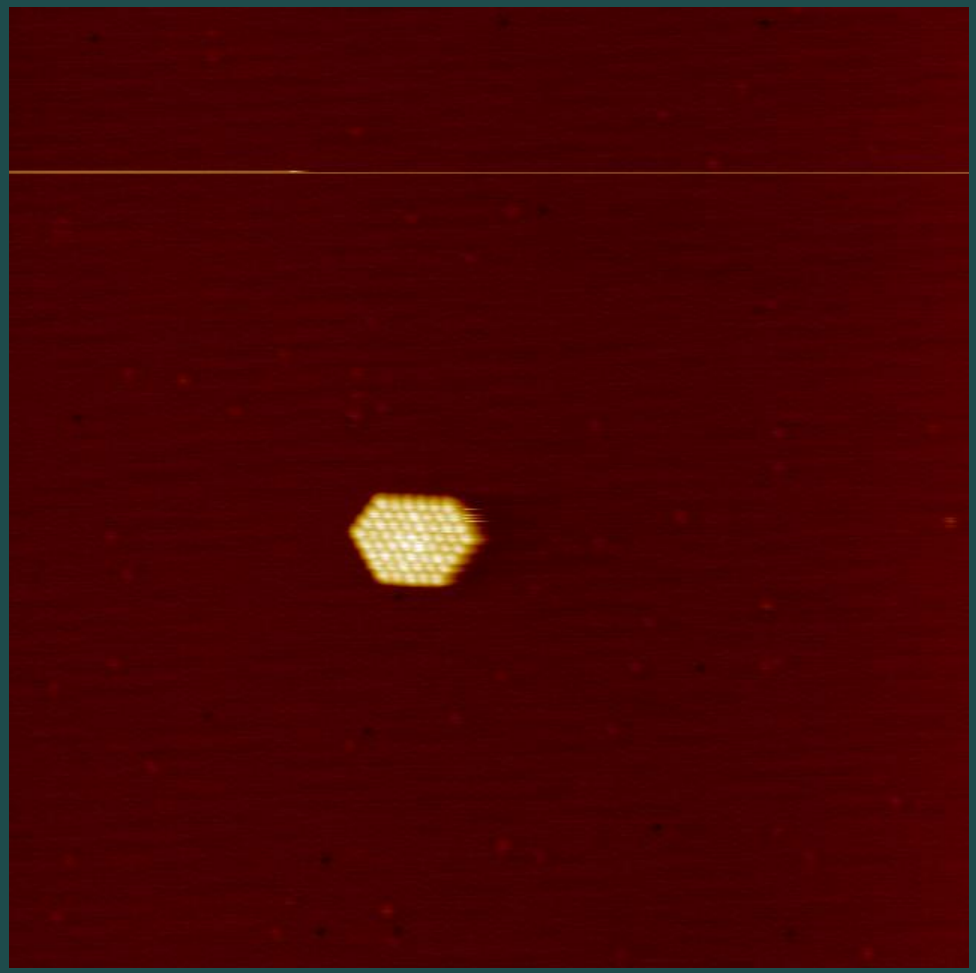
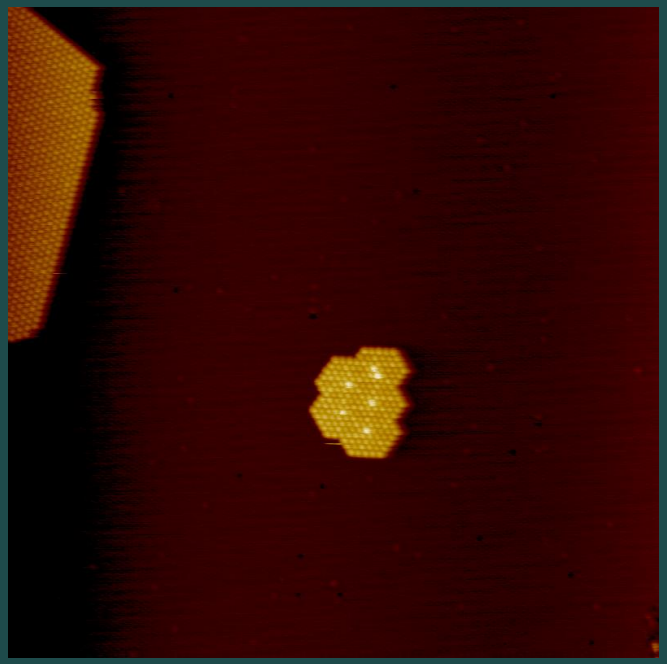
STM movie showing the stepwise growth of a C_{60} Island



When C_{60} flux is switched on, the 56-mer starts to grow through the successive formation of the high-generation magic islands. This growth in the island size exhibits a stepwise dependence versus C_{60} deposition time.



The ‘magic’ C_{60} island grows predominantly from the right lower side due the presence of a huge 19.1º-rotated C_{60} island from its upper side, which acts as a strong sink for mobile C_{60}.

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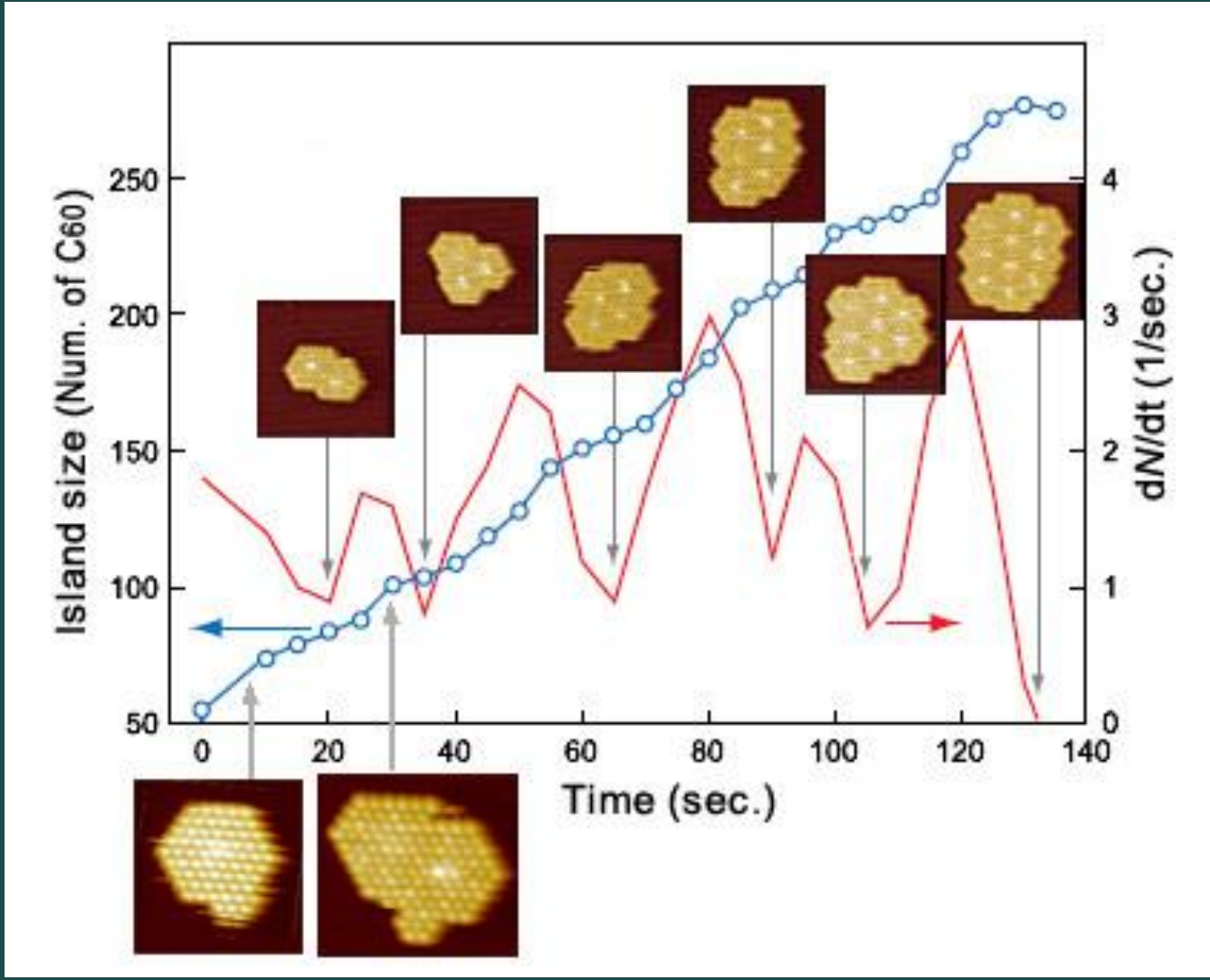

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Formation of C_{60} Surface Magic Clusters (SMC) on the Si(111)-√3×√3-(Au,In)

Theoretical Understanding

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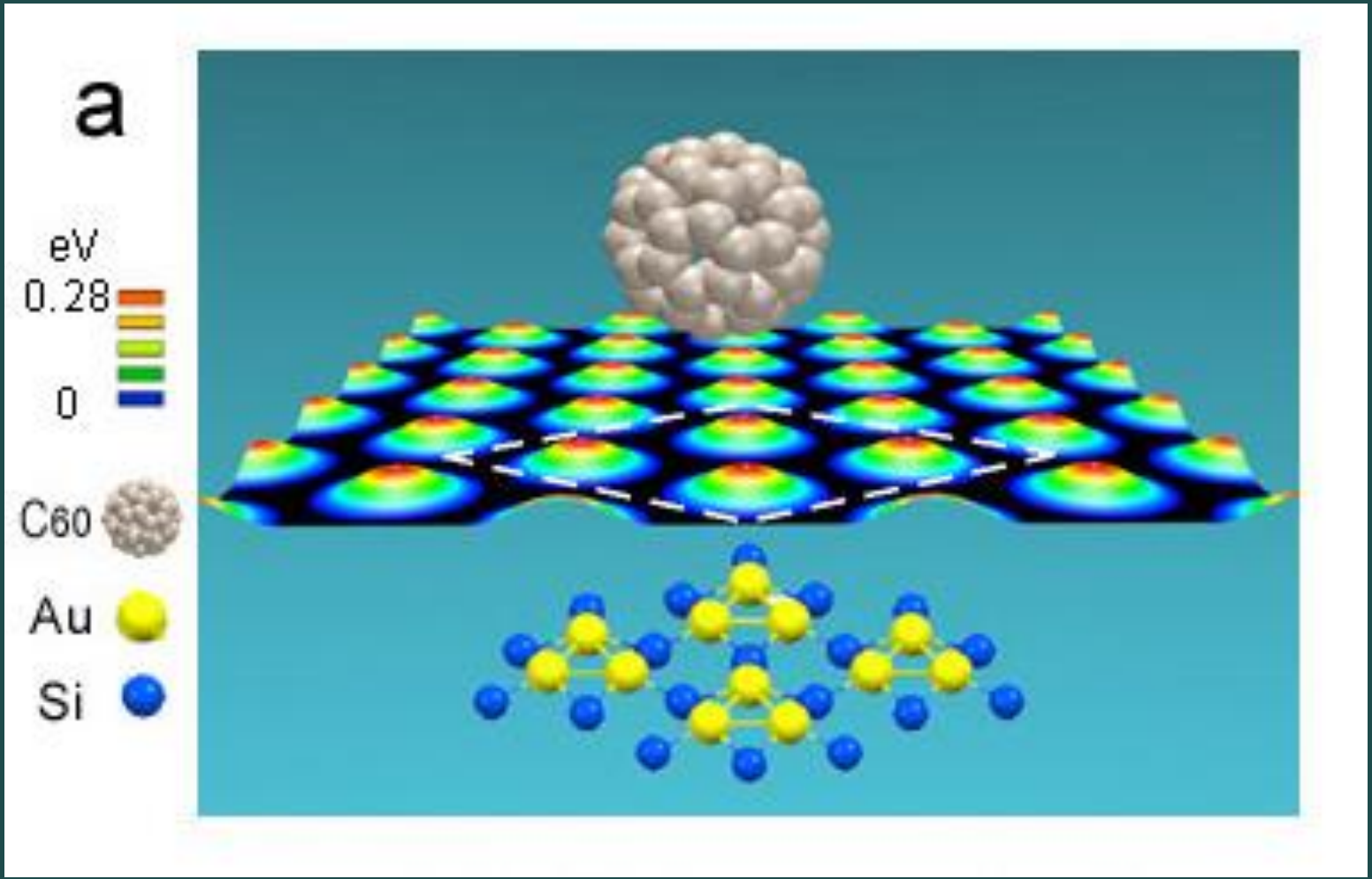
Adsorption Energy of C_{60} on the Si(111)-√3×√3-(Au,In) surface



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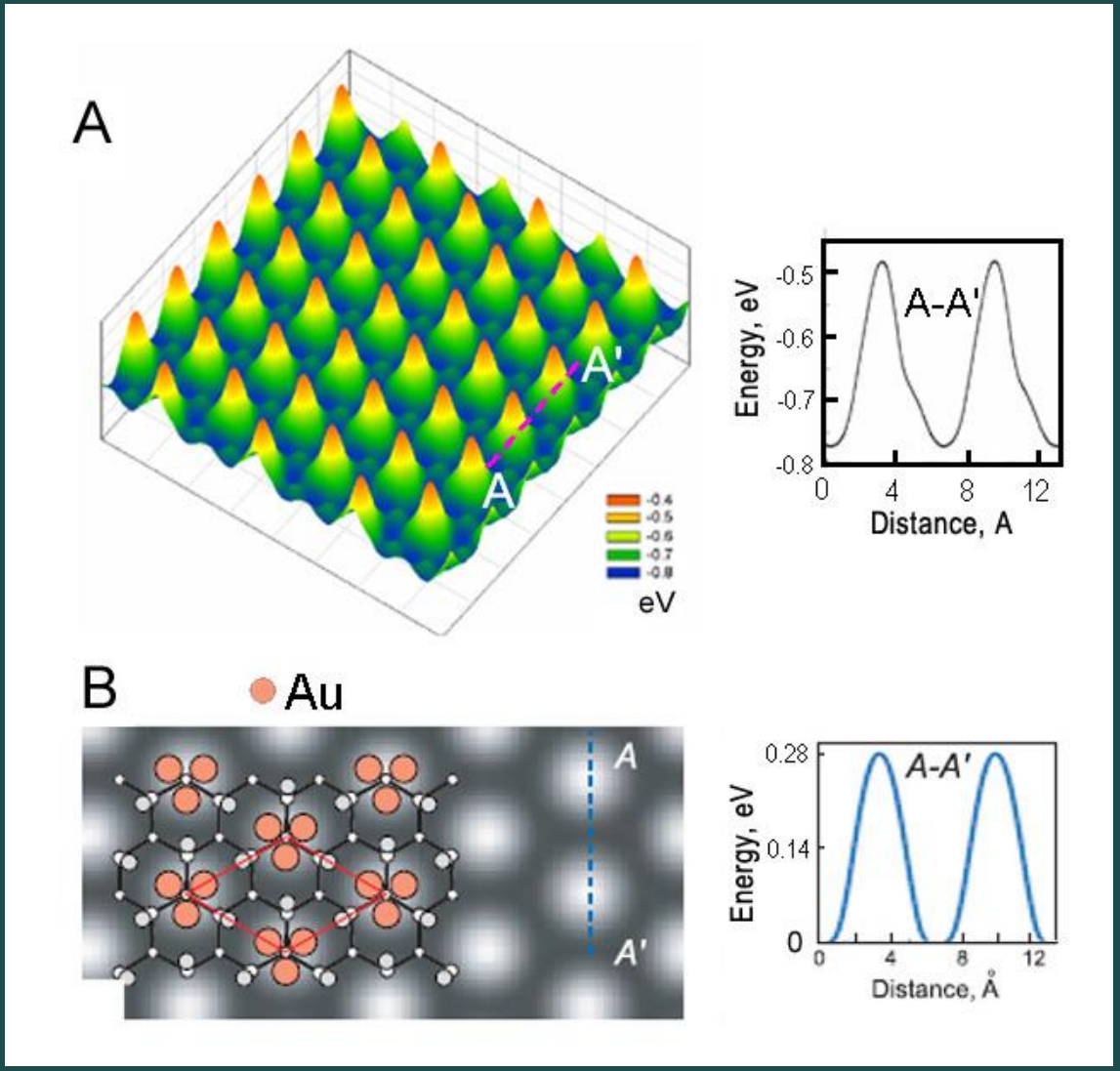

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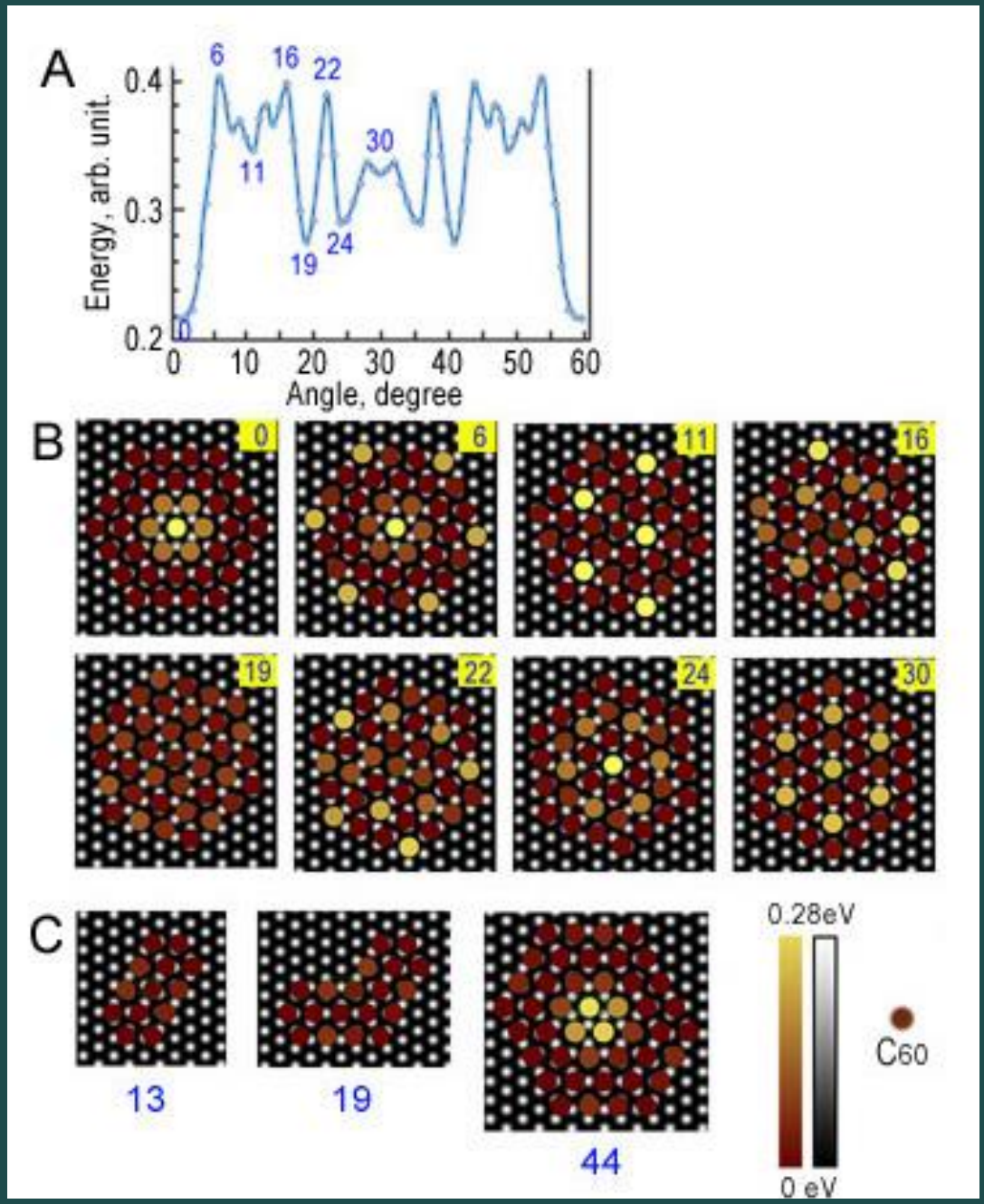

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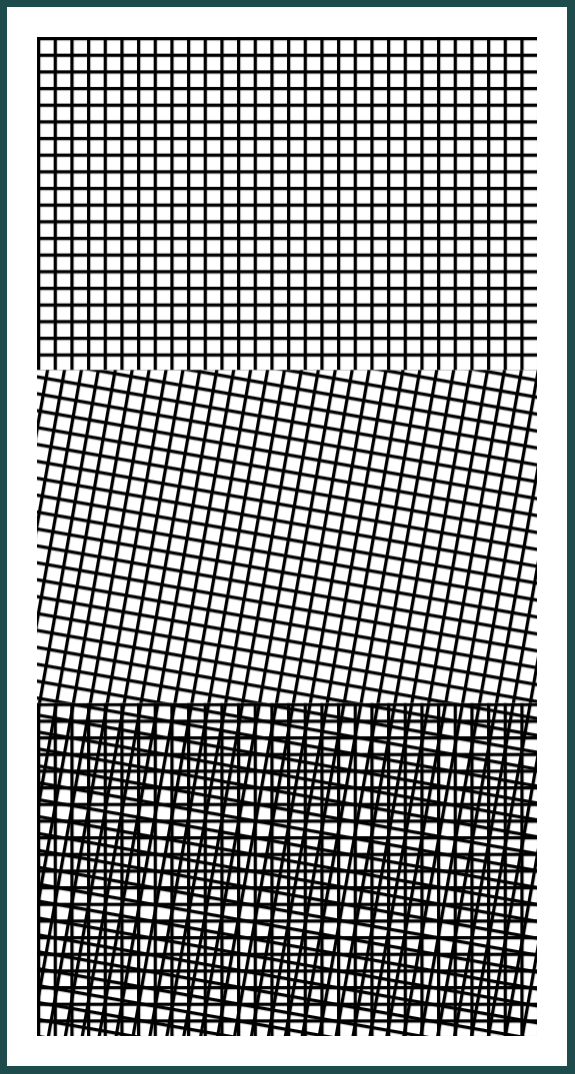
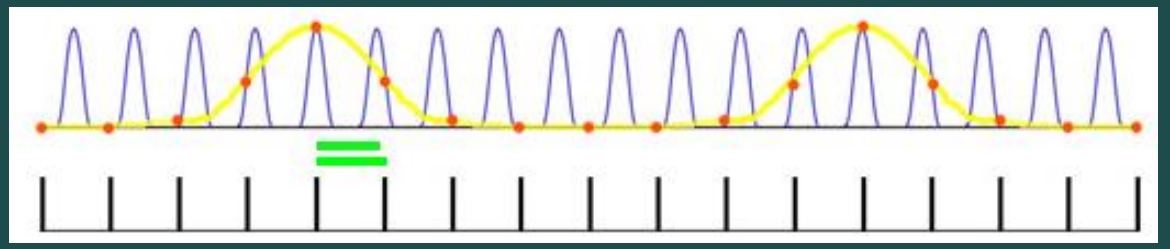
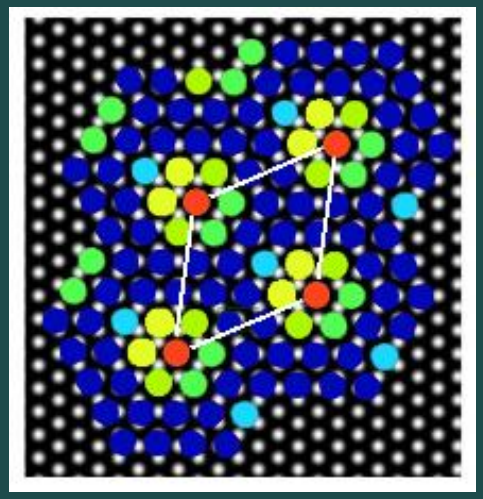
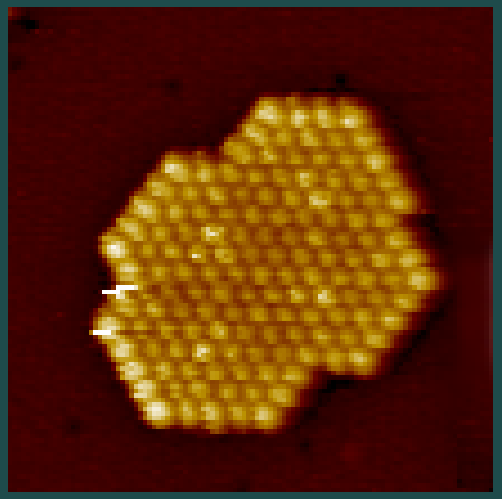
Moiré Pattern & Moiré Magnifiers





http://en.wikipedia.org/wiki/Shape_moiré





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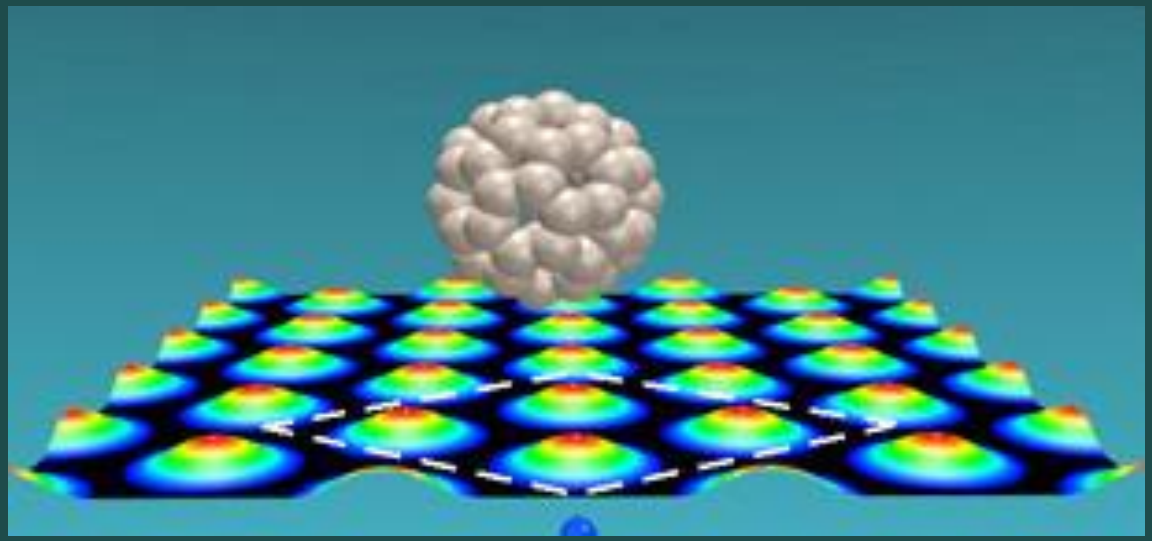
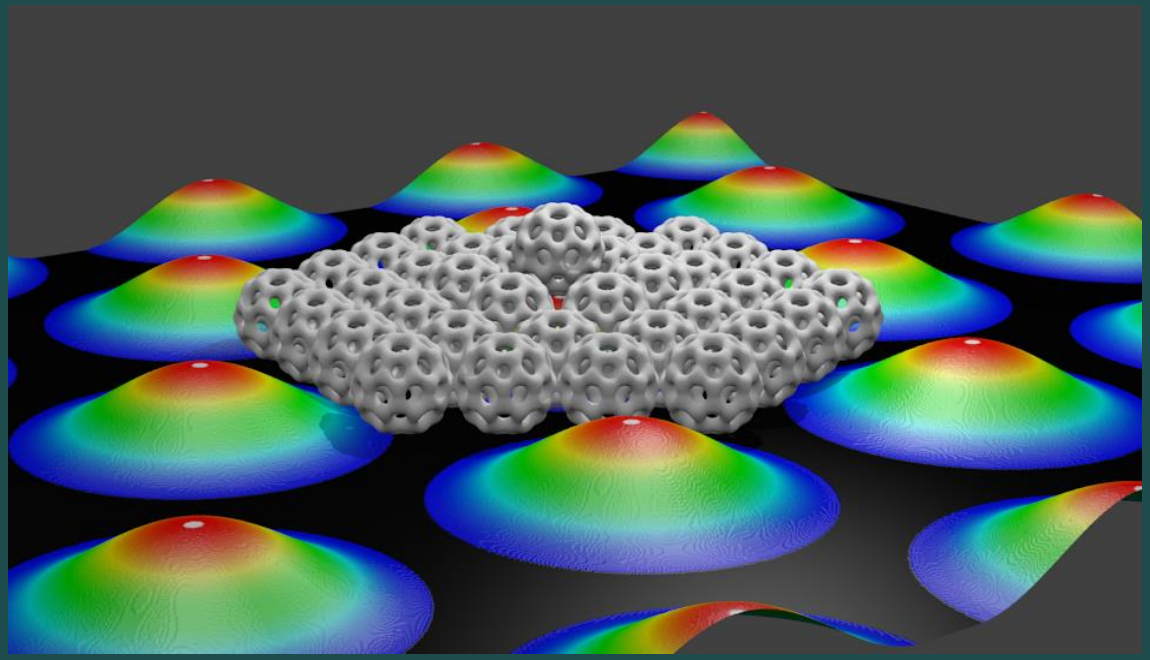
Atomic Scale Moiré Magnifiers



length scale is scaled up by a factor of $\sqrt{19}/(\sqrt{3}\times 0.384)$, ~6.5



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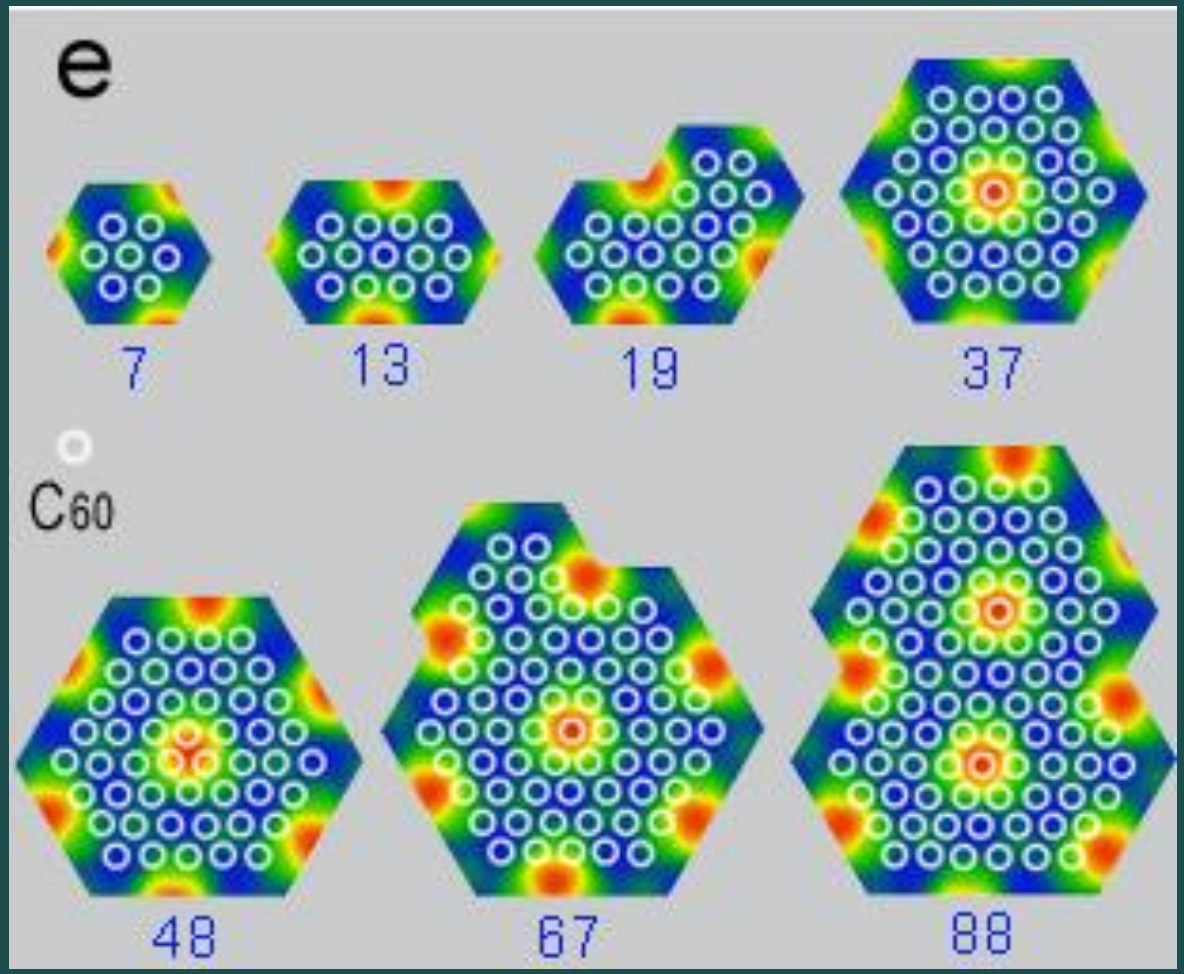
Size Selection of C_{60}-Islands Mediated by by Atomic Scale Moiré Magnifiers



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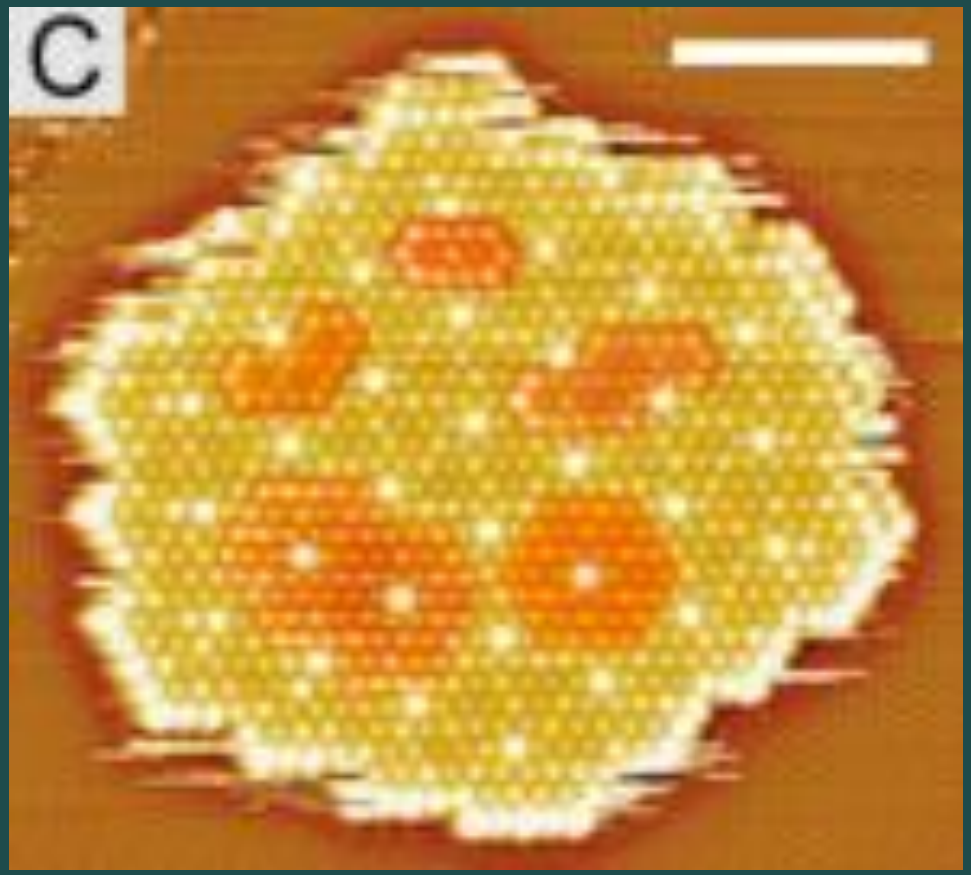
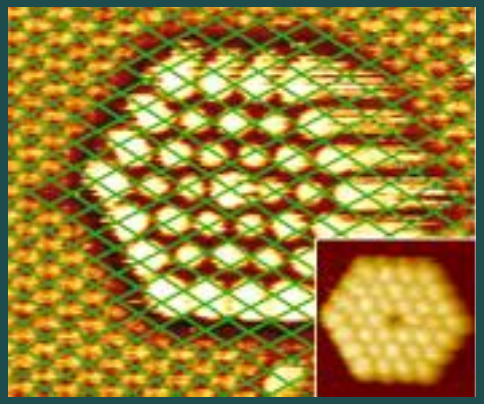
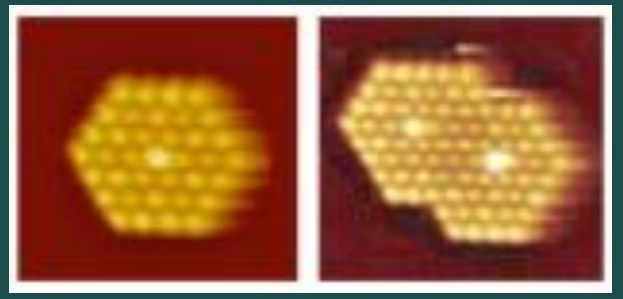
Size Selection of C_{60}-Islands Mediated by by Atomic Scale Moiré Magnifiers







Scale bar is 10 nm

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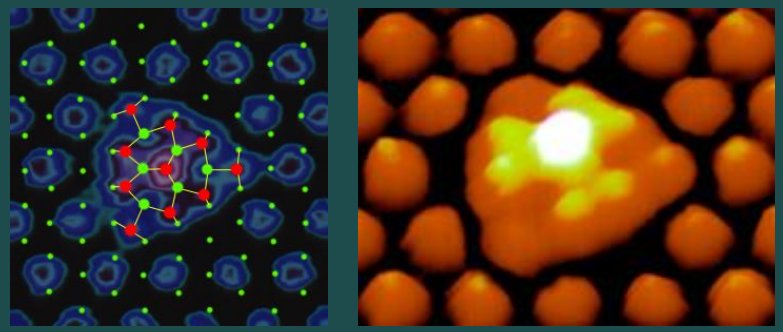
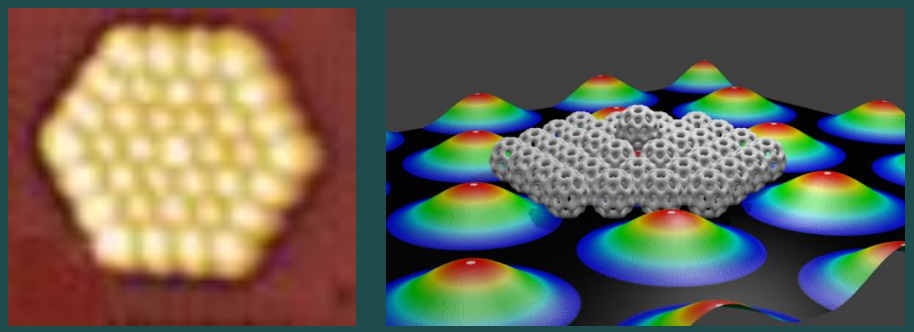
Conclusions

The moiré interference pattern between the C_{60}-layer and substrate mediates the size selection of 37-mer SMC.

The concepts of moiré-shell-closure and moiré magnifier could be exploited for the creation of mono-dispersed atomically precise nanostructures by self-assembly.



10 Ga (PRL 1998)



37 C_{60}= 2220 C (Nat. Comm. 2013)

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We Thank You for Your Attention

Alex Saranin & Andrey Zotov

Institute of Automation and
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