Origin of Structure

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What causes structure?

- Principle cause: primordial curvature perturbation $\zeta(\mathbf{x})$, existing at $T \sim 10\,\mathrm{keV}$
  - Determines perturbation in energy density ρ.
- Maybe also primordial isocurvature perturbation (perturbation in number density of baryonic matter, CDM or neutrino at fixed ρ)
  - But observation demands $<$ few percent and no reason for it to be near that level.
- Maybe also cosmic strings.
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From some other light scalar field perturbation?
Does a light vector field perturbation contribute?
(Needs coupling $RA^2/6$ to gravity, or kinetic function $\propto a^{-1\pm3}(t)$.)

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I'll mention all network papers on arXive since Sept 1st 2009, that I've been told about.

Then I'll survey developments of past few years, and predict the future.

Inflaton paradigm: slide 1

Hybrid inflation: the INFLATON within SM or beyond SM (Einstein Gravity), the WATERFALL FIELD invoked just for inflation

Tamvakis (Ioannina, CERN) 0911.3730
Supersymmetric Inflation with the Ordinary Higgs

Tamvakis (Ioannina, CERN) 0912.3368
Inflation with the right-handed neutrino revisited

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Inflection point inflation within supersymmetry.

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Higgs inflaton, non-hybrid with coupling $\propto R|H|^2$

Lerner and McDonald (Lancaster) 0912.5463
Higgs inflation and naturalness

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A unitarity-conserving Higgs inflation model

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A unitarity-conserving Higgs inflation model

Buck, Fairbairn and Sakellariadou (KCL) 1005.4276
Inflation in models with conformally coupled scalar fields: an application to the noncommutative spectral action.
(Considers also Connes' 'noncommutative' SM)

Inflaton paradigm: slide 2

Hybrid inflation, the inflaton a PNGB

Ross and German (Oxford) 1002.0029

Hybrid natural low-scale inflation.

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Inflaton kinetic term non-minimally coupled to gravity

Germani and Kehagias (Paris and NTUA) 0911.4128

A new type of scalar field inflation.

Germani and Kehagias (Paris and NTUA) 1003.2635

New model of inflation with non-minimal derivative coupling of SM Higgs boson to gravity.

Germani and Kehagias (Paris and NTUA) 1003.4285

Cosmological perturbations in the new higgs inflation.

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DBI inflation

Brax and Cluzel (CEA Saclay) 0912.0806

Brane bremsstrahlung in DBI inflation.

Inflaton paradigm: slide 3

Inflaton $=$ CDM: invokes coupling $\propto R|\phi|^2$

Lerner and McDonald (Lancaster) 0909.0520

Gauge singlet scalar as inflaton and thermal relic dark matter

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Better constraints on n and r

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Single-field inflation constraints from WMAP5 and SDSS data.

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Modular inflation ie. non-hybrid with $V = V_0 f(\phi/M_{\rm P})$

Cicoli and Mazumdar (Lancaster and Bohr Inst.) 1005.5076

Reheating for closed string inflation.

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Search for evidence of features in spectrum

Hamann, Shafieloo and Souradeep (Oxford) 0912.2728

Features in the primordial power spectrum? A frequentist analysis.

A model giving features (phase transitions during inflation)

Hotchkiss and Sarkar (Oxford) 0910.3373

Non-gaussianity from violation of slow-roll in multiple inflation.

Curvaton paradigm

Small corrections to quadratic potential (needs $\epsilon > 0.02$)

Engvist and Takahshi (Helsinki) 0909.5362
Effect of Background Evoloution on the Curvaton Non-Gaussianity

Enqvist, Nurmi, Taanila and Takahashi (Helsinki) 0912.4657
Non-gaussian fingerprints of self-interacting curvaton.

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Very light curvaton (needs decay rate 10^{-7} eV!)

Enqvist, Mazumdar and Taanila (Helsinki, Lancaster) 1007.0657
The TeV-mass curvaton.

Contribution to ζ from vector field

Smoking gun: statistical anisotropy

Single vector field

Valenzuela-Toledo, Rodriguez and Lyth (Lancaster) 0909.4064
Non-gaussianity at tree- and one-loop levels from vector field perturbations.

Dimopoulos, Karciauskas and Wagstaff (Lancaster) 0909.0475
Curvaton without instabilities.
(Spectrum of ζ can be isotropic if $m \propto a(t)$, then no need for scalar fields.)

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On the health of a vector field with $RA^2/6$ coupling to gravity
(We're not dealing with a 'ghost'.)

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Non-abelian gauge field multiplet

Bartolo, Dimastrogiovanni, Mataresse and Riotto (CERN) 0906.4944
Anisotropic bispectrum of curvature perturbations from primordial non-Abelian vector fields

Bartolo, Dimastrogiovanni, Mataresse and Riotto (CERN) 0909.5621
Anisotropic trispectrum of curvature perturbations from primordial non-Abelian vector fields

(Evaluated at horizon exit: subsequent evolution might dominate)

Odds and ends

A heavy scalar field perturbation, $\mathcal{P}_\zeta \propto k^3$

Lyth (Lancaster) 1005.2461

Issues concerning the waterfall of hybrid inflation

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Cyclic universe

Biswas, Mazumdar and Shafieloo (Lancaster and Bohr Inst) 1003.3206

Wiggles in the cosmic microwave background radiation: echoes from non-singular cyclic inflation.

Reviews

Karciauskas (Lancaster) 1009.1779 (PhD Thesis)
Quantum Fluctuations of Vector Fields and the Primordial Curvature Perturbation in the Universe.

Mazumdar and Rocher (Lancaster and Bohr Inst.) 1001.0993
Particle physics models of inflation and curvaton scenarios.

Allahverdi, Brandenberger, Cyr-Racine and Mazumdar (Lancaster and Bohr Inst.) 1001.2600
Reheating in inflationary cosmology: theory and applications

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GUT hybrid inflation, inflaton **and** waterfall field having the gauge interaction.
Antusch, Bastero-Gil, Baumann & Dutta, 1003.3233.

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SO LOT'S OF FORTHCOMING DATA MAKING FOR A VERY HEALTHY AREA OF RESEARCH.