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Abstracts of recently accepted papers

The Structure of Optical Stellar Jets: a Phenomenological Analysis

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In this paper we discuss the possible mechanisms of formation ot the nodular structure of Herbig-Haro jets. The available spectral observations of the linear jet section in the HH 34 and the HH 111 complexes are reviewed, in order to diagnostic the temperature and ionization state of the emitting material in a way as model-independent as possible. The values we find by means of an original although straightforward diagnostic procedure (T $\sim$ 6000 K, $x = n_{H^+}/n_H \sim 0.1$, in both cases), are similar to those empirically determined by Brügel et al. (1981) and Böhm and Solf (1990) for the compact object HH 7.

Our results lead to a value of the momentum rate in these flows comparable to the rates observed in high-speed neutral winds (Lizano et al. 1988), giving support to the view according to which the bright optical jet actually identifies the axial portion of the neutral flow, and marks the location where the matter attains its maximum velocity and an observable amount of ionization. The ionization derived from the observations is likely to be a remnant of the heating and the excitation occurred in the accelerating region, where the wind is probably focused by the passage through a nozzle. The recombination time scale appropriate for the rather low electron densities in the jet is found to be close to the crossing time of the visible portion of the jet.

Combining kinematical and energetic considerations we show that physical conditions consistent with the observed jet's emission can be obtained through "soft" compressions of the central portion of the flow, caused by 'damped' Kelvin-Helmoltz instabilities generated at the jet-ambient contact discontinuity. These compressions concentrate in smaller volumes the already available internal energy that is eventually radiated in optical and IR lines, unlike the weak shocks that actually increase the internal energy content by transforming the bulk kinetic energy into thermal random motions. A picture of this kind seems capable of resolving the long-standing problem of conciling the high supersonic velocity of the ionized material and the low excitation nature of the emission, and, at the same time, provides a very natural explanation for a number of observational constraints, among which the increase of the [SII]/Hα ratio along the jet and the disappearance of the optical emission after a characteristic scale length.

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LkHα 198 Revisited

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This paper examines the nature of deeply embedded sources found in association with optically visible Herbig Ae/Be stars, such as the recently discovered 10 μm object LkHα 198-IR. The possibility that such deeply embedded objects, instead of the optical stars, are responsible for the extended far-infrared emission detected by the Kuiper Airborne Observatory is investigated by using three types of models. The first considers LkHα 198-IR to be a star embedded in a dense cloud and the only source responsible for the far-infrared emission. The second set of models replaces the embedded star with an embedded star+disk system. The third set of models has both LkHα 198-IR and LkHaα 198-OP (the optical star) as sources of equal luminosity, where LkHα 198-IR is in the center of a dense cloud and the optical star is at the edge. We argue, based on these results, that the extended far-infrared emission is most likely associated with LkHα 198-OP, and, more generally, that the extended far-infrared emission seen around many Herbig Ae/Be stars is associated with the known optical star rather than any deeply embedded companion.

By combining our models with existing sub-millimeter observations, we suggest that in the LkHα 198 region we are seeing a roughly spherical cloud of moderate mass and thickness, characterized by a rather flat density, which contains LkHα 198-OP and, possibly, LkHα 198-IR. The large extinction toward the latter, revealed by the deep 10 μm absorption feature seen against it, is best explained as arising in a thick circumstellar disk.

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Physical Properties of Dense Cores: DCO$^+$ Observations

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We conducted a survey for $C^{18}O$, DCO^+, and $H^{13}CO^+$ J=1$\rightarrow$0 emission in a sample of low mass cores previously surveyed in CS, NH_3, and C_3H_2. The DCO^+ and $H^{13}CO^+$ observations were used to test deuteration fractionation chemistry models for TMC-1 type clouds. The [DCO^+/HCO^+] fractionation ratio (0.045$\pm$0.014) was found to be in excellent agreement with current models. In addition, we did a multiple transition study of DCO^+ emission which revealed the presence of denser gas ($n \propto 10^5$ cm^{-3}) than most previous molecular line studies of these cores had found. The observations also suggested that those cores which are associated with young stars have slightly higher densities on average than those cores which have no associated star. We also found DCO^+ linewidths for the cores studied are significantly broader than the previously observed NH_3 linewidths. The DCO^+ linewidth broadening does not appear to be entirely an opacity effect. Instead, the broader linewidth suggests the presence inside the core of a dense supersonic gas component not traced by NH_3.

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Magnetized accretion-ejection structures III-Stellar and extragalactic jets as weakly dissipative disk outflows

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The production of jets from a Keplerian accretion disk, thread by a bipolar magnetic field, is considered as a successful paradigm for young stellar objects (YSOs) and Radio Loud active galactic nuclei (AGN). However, while the

acceleration of the jet is understood, the issue of the expell of a part of the matter from the disk is still an enigma. In this paper, we elucidate the physical process that leads to ejection, exhibit the conditions allowing the steady state launch of jets and expound the properties of these magnetized accretion-ejection structures.

As in a huge Barlow wheel, the magnetic field lines extract all the angular momentum and the mechanical power from the disk, while a turbulent magnetic diffusivity allows the matter to pass through the field lines and thus, to be accreted. Because of the disk differential rotation, the radial current decreases as one goes upwards in the disk atmosphere, leading then to a change of sign of the magnetic torque. From this point on, both angular momentum and energy are transfered back to the matter. Magnetic azimuthal acceleration leads to the increase of the angular velocity which drives an outwards radial velocity, while the magnetic pressure associated to the horizontal field develops a vertical acceleration. Hence, magnetically driven jets can be seen as being both centrifugally and magnetic pressure driven. At the still resistive base of the jet, the magnetic force pushes matter towards the magnetic surfaces. A transition between the resistive disk and the ideal MHD jet is then naturally achieved.

The intrinsic two-dimensionality of the problem arises as a regularity condition that must be satisfied, in order to smoothly break through a slow magnetosonic critical point. We derive the observational signatures of such a disk, as well as the global energy budget and its consequences on the jets, depending on the mass ejection rate. Magnetized accretion disks supply their jets with almost all the available gravitational power, being then weakly dissipative. We discuss the possibility for the disk to be either convective or radiative, in regard to its settlement around a young stellar object, or within an active galactic nuclei. Self-consistent solutions are displayed in the context of AGN and YSOs.

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The NGC 7538 IRS 1 Region of Star Formation: Observations of the H 66α Recombination Line with a Spatial Resolution of 300 AU

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The 1.3cm continuum and the H 66α recombination line emission toward NGC 7538 IRS1 have been imaged with a spatial resolution of 180 & 300 AU respectively. There are several remarkable aspects to the data. The core of the HII region is composed of numerous emission clumps with peak brightness temperatures of $\approx$ 15,000K. Extremely wide line profiles, 250 km s^{-1} FWZP, are observed from the core, indicating substantial mass motions of the ionized gas. The H 66α spectral profiles exhibit multiple emission peaks. The peaks and shapes of the H 66α recombination line profiles vary significantly as a function of position within the core region. The H 66α line-to-continuum ratios also vary considerably within the core region. A thin strip midway between the northern and southern core continuum components is the region of largest electron density. The center of this dense, disk-like structure most likely delineates the positi! on of the exciting star.

We present a model for NGC 7538 IRS1 that involves a stellar wind outflow and photoevaporation of nearby clumpy neutral material. This results in a clumpy continuum appearance and a complicated set of broad and multiple peaked spectral profiles. Ionized gas escapes the core region in an outflow to the north and south. Toward the south the outflow is partially limited by neutral material, producing a southern, spherical continuum component which exhibits much narrower H 66α line profiles than the core region.

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Effect of gas drag on the dynamics of protostellar clumps in molecular clouds

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Molecular clouds are observed to have sub-structure within them and consist of dense condensations or clumps which are surrounded by a less dense inter-clump medium. The inter-clump gas could retard the motion of the clumps in the cloud through a drag force caused by dynamical friction. The effect of such a drag force on the dynamics of protostellar clumps in a molecular cloud has been numerically analysed. Since the forces are mass dependent, the more massive clumps suffer greater drag and settle towards the centre in shorter timescales. This causes a radial segregation with respect to mass of the clumps in the cloud. This segregation induced by dynamical friction is found to be significant for protostellar clumps in interstellar clouds as the timescale involved is much shorter than the typical cloud lifetime or the N-body relaxation time.

The segregation is more pronounced and quicker in denser clouds. Variations in clump mass spectra and density profile of interclump gas have little effect on the dynamics, and do not affect the timescale of segregation in the cloud system very much. There is also some velocity segregation with respect to mass, with the more massive clumps tending to have lower velocities. This is not, however, as pronounced as the spatial segregation. The most massive star-forming clumps are thus expected to be closer to the centre of the parent cloud. Subsequent star formation in these clumps could then explain the mass segregation observed in many young clusters of pre-main sequence stars and YSOs.

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Ageing Jets from Low-Mass Stars

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An extended faint optical jet is associated with the compact emission region plus faint star known as HH 55. HH 55 is located in the Lupus 2 cloud 2′ SW of the well studied T Tauri star RU Lupi. The HH 55 jet extends 55″ N and 35″ S in PA 160°. The HH 55 star is an emission line star of spectral type M3.5. Its image in the emission lines of Hα and [S II] is slightly elongated by $2-3''$ to the S but in continuum light is symmetrical and pointlike (FWHM = 1.7″). The star and jet have several features in common with the star and jet known as Sz 102 = Th 28 in the nearby Lupus 3 cloud. We suggest that these objects are representative of the late evolutionary stage of the HH jet-outflow phenomenon and point out that such objects may be quite common although difficult to detect. With $L_{bol} \sim 0.005 L_\odot$ and log $T_e \sim 3.5$, the HH 55 star is close to the main sequence and evolutionary tracks suggest an age of 3×10^7 years.

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A Multitransitional Study of the Cep C Cloud Core

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Strip maps of ^{12}CO, ^{13}CO, and C^{18}O J=2-1 and J=1-0 emissions from the Cep C dense core have been obtained to determine its density distribution and kinematic properties. Using large velocity gradient models to estimate gas conditions, The H_2 volume density ranges between 2500 cm^{-3} at the core edge to 7000 cm^{-3} at the central position. Absorption features are found in the ^{12}CO lines which are redshifted with respect to the cloud core velocities. Self-absorption is also identified in the profiles of ^{13}CO J=2-1 emission but at velocities much closer to those of the central core of the line. Such velocity structure denotes different kinematics and thermal conditions within several layers of material along the line of sight.

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Doppler Imaging of the T Tauri Star HDE 283572

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We present Doppler images of the surface temperature distribution of the rapidly rotating weak-emission line T Tauri star HDE 283572, as computed from the FeI λ6400Å, FeI λ6393Å, CaI λ6439Å, and LiI λ6707Å photospheric lines. This analysis reveals the presence of one large polar structure 1600 K colder than the surrounding photosphere. We also find a possible rotational modulation of the H_α and CaII equivalent line widths that suggests the presence of large-scale chromospheric structures above the stellar surface.

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Spatially Resolved Submillimeter Continuum Emission Toward L1551 IRS-5

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We present high signal-to-noise ratio 16–20″ resolution submillimeter continuum images of the embedded young stellar object L1551 IRS-5. The images are dominated by a compact source at the position of IRS-5, which has a deconvolved size of $10 \pm 3''$. Low level emission extends up to 5000 A. U. from IRS-5 and is distributed non-axisymetrically. The 1100μm emission is extended in the north-south direction and elliptical in shape. In contrast, our 730μm map shows emission in a cross-shaped pattern, with arms extending to the north, south, east, and west of IRS-5. The cross emission is not an artifact of our observational methods, but intrinsic to the source distribution. We model the submillimeter continuum emission at 1100μm and 730μm using three components: an unresolved point source; a cold (~12 K), massive (~ 1 $M_\odot$), smoothly-distributed envelope; and a warm (≥ 50 K), less massive (≤ 0.02 $M_\odot$) "cross" centered at the position of IRS-5. We note that the arms of the cross are well-aligned with the edges of the CO outflow from IRS-5, and suggest that they may consist of core material warmed and pushed aside by the energetically-dominant outflow.

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Star Formation in Groups

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In order to study the relation between clustering and binary formation, the analysis by Gomez et al. (1993) of the clustering of young stars in the Taurus region has been extended to smaller separations by using data from recent searches for close companions to these stars. The Taurus young stars are found to exhibit self-similar or fractal clustering on the largest scales, but there is a clear break from self-similarity at a scale of about 0.04 pc which divides the regime of binary and multiple systems on smaller scales from that of true clustering on larger scales. This break provides clear evidence for the existence of an intrinsic scale in the star formation process, and this scale is found to be essentially equal to the Jeans length in typical molecular cloud cores. The associated mass is of the order of one solar mass, supporting the hypothesis that typical stellar masses are determined by the Jeans mass. Both the self-similar clustering of the Taurus stars on the larger scales and the power-law form of the upper stellar IMF may have their origin in hierarchical and perhaps fractal-like cloud structure. The very different distribution of stellar separations that is observed in the regime of binary and multiple systems strongly suggests that these systems are not formed in the same way as the hierarchical clustering, but by a distinct mechanism which is probably the fragmentation of collapsing clumps of about the Jeans size. The evidence suggests that nearly all stars are formed in binary or multiple systems, and that some of these systems are subsequently disrupted by interactions in the denser star-forming environments to produce the observed mixture of single, binary, and multiple stars.

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Discovery of a molecular hydrogen jet near IC 348

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We present near-infrared images of a newly discovered molecular hydrogen jet (HH 211) near the young stellar cluster IC 348 in the Perseus dark cloud complex. A wide-field true-colour JHK' image locates HH 211 relative to the embedded source IC 348-IR, and a high-resolution image taken in the H_2 v=1–0 S(1) line at 2.122 μm delineates the shock-excited gas. The jet is very young, with a dynamical age of < 1000 yrs. We suggest that the H_2 emission arises in a turbulent sheath around the true jet, leading to an unusual symmetric limb-brightened appearance. This boundary layer is probably where ambient molecular material is being entrained to form a coincident bipolar CO outflow. We discuss possible models for the knots in HH 211, including internal working surfaces in an episodic outflow and crossing shocks in a recollimating jet. The exciting source of the jet and outflow was detected at $\geq$350 μm, and our observations imply that the exciting source is a young star deeply embedded in a dense NH_3 core, perhaps an edge-on circumstellar disk. The HH 211 system of jet, molecular outflow, and embedded exciting source is the first discovered through near-infrared imaging.

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(A preprint version of this paper may be obtained via anonymous `ftp` or the World Wide Web. For the former, connect to `spitfire.mpia-hd.mpg.de`, login as `ftp`, using your e-mail address as password, `cd preprints`, and `get README` for further instructions. Using WWW, connect to `http://spitfire.mpia-hd.mpg.de/Preprints.html` and follow the relevant links to this paper.)

A simulation of an HH jet in a molecular environment

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The heads of some Herbig-Haro (HH) jets have recently been detected in emission lines of molecular species such as H_2 and CO. In this paper we present an axisymmetric numerical simulation of an atomic, nonadiabatic jet moving into a molecular environment, from which predictions of intensity maps in atomic/ionic and molecular emission lines can be carried out. While the maps predicted from these models for emission lines of atoms and ions have the expected bow-shaped structure, the maps for H_2 lines have a "hole" in the stagnation region of the bowshock, where the molecules are dissociated. The morphology predicted for the molecular emission intensity maps is in clear qualitative agreement with recent observational results. We also present predictions of position-velocity diagrams, which will be useful for comparisons with future long-slit spectroscopic observations of HH objects.

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Molecular mixing layers in stellar outflows

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Molecular outflows possibly are the result of the interaction between a high velocity jet from a young star and the surrounding molecular environment. This interaction can take place through the formation of a turbulent mixing layer. We present models of a plane mixing layer in the boundary between a high velocity, atomic wind (the stellar jet) and a stationary, molecular environment, which are computed considering a detailed chemical network.

The chemical composition of the mixing layer initially corresponds to the direct mixture of the (atomic) jet and

(molecular) environmental material. However, we find that the mixing layer is hot (with temperatures exceeding 10^4 K), so that the mixing layer quickly becomes "chemically active", especially since H_2 molecules are only partially dissociated. A number of molecules are either created or survive in the high velocity flow.

The emission from such atomic jet/molecular environment mixing layers is dominated by emission in the rotational and vibrational lines of H_2. As a result of the high temperatures ($\sim 10^4$-10^5 K) and velocities (ranging from zero to the jet velocity) of these mixing layers, the predicted H_2 emission line spectrum has characteristics that are interestingly different.

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X-ray Emission from Herbig Ae/Be stars: A ROSAT survey

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We have observed 14 Herbig Ae/Be stars in X-rays with the ROSAT PSPC (0.1 – 2.4 keV). In addition, we obtained data from the ROSAT archive for 7 Herbig Ae/Be stars. As a result, 11 of the 21 Herbig Ae/Be stars studied here have been detected as X-ray sources, among them AB Aur, HR 5999/6000, and Z CMa. This is surprising, since Ae/Be stars, being predominantly radiative, are unlikely to sustain dynamo magnetic fields and coronal heating. We have investigated possible correlations between the X-ray luminosity and other stellar parameters like $L_{\rm bol}$, spectral type, stellar rotation and winds. We suspect that the origin of the X-ray emission is likely to be related to the stellar wind, although other explanations (e.g. unresolved T Tauri companions) are also discussed. Some Ae/Be stars are known to be the exciting sources of high-velocity jets, but none of the jets themselves were detected in X-rays. In several cases, the X-ray images revealed a small cluster of sources, presumably lower mass pre-main-sequence objects that surround the more massive Ae/Be stars.

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(A preprint of the paper (TeX file and figures as Postscript files) can be obtained per e-mail from Th. Preibisch)

IAU Symposium 170

CO: Twenty-five Years of Millimeter-wave Spectroscopy

A symposium to celebrate the 25th anniversary of the detection of carbon monoxide.

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Symposium Objective:

Interstellar carbon monoxide (CO) and several other basic molecules were first detected twenty-five years ago with the 36-foot telescope of the National Radio Astronomy Observatory. These discoveries have profoundly influenced our understanding of several diverse yet interrelated fields, including the phases of the interstellar medium, the initial and final phases of stellar evolution, the chemistry of dense and diffuse interstellar matter and the solar system, the structure of the Milky Way galaxy, and the content and structure of other galaxies. These research areas are among the most fundamental in astrophysics, and the spectroscopic information provided by CO and other molecules serves as the primary tool of investigation. New developments in instrumentation will further increase the power and utility of molecular line spectroscopy. The twenty-fifth anniversary of the detection of CO is a timely opportunity to bring researchers in all these areas together to review progress and discuss future directions. The emphasis of the meeting will be on CO and other molecules as tracers and diagnostics: what we have learned from CO and what remains to be learned

General Topics to be Discussed:
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- Future directions

Additional details are available. See the NRAO World Wide Web information pages for occasional updates (Go to http://info.aoc.nrao.edu/ and click for information on the Tucson site.).

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New Books

Stellar Jets and Bipolar Outflows

Proceedings of the Sixth International Workshop of the Astronomical Observatory of Capodimonte (OAC 6), held at Capri, Italy, September 18-21, 1991.

Edited by L.Errico, Alberto A Vittone

Astrophysics and Space Science Library 186

The book contains the oral and poster presentations from the Capri meeting. Discussions after the talks are also included. The following are the invited reviews presented:

S. Cabrit: *Molecular Outflows from Young Stellar Objects*

R. Mundt: *Observational Properties of Jets from Young Stars*

F. Paresce: *Observation of Circumstellar Environments with the Hubble Space Telescope*

J. Solf: *Bipolar Outflows and Jets from Central Stars of Planetary Nebulae*

A.M. Cherepashchuk: *Parameters of SS 433 as a Massive Binary System*

T.P. Ray: *Interpreting Jets from Young Stars*

A. Königl: *The Origin of Energetic Outflows in Young Stellar Objects*

M. Camenzind: *Magnetic Fields, Disk Winds and Jets in Astrophysics*

G.S. Bisnovatyi-Kogan: *Mechanism of Jet Formation*

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The Star Formation Newsletter is available on the World Wide Web. You can either access it via the ESO Portal (http://http.hq.eso.org/eso-homepage.html) or directly in two ways: by issue number (http://http.hq.eso.org/star-form-newsl/star-form-list.html) or via a wais index (wais://http.hq.eso.org:2010/starform).

Herbig-Haro Object Catalog and Star Formation Newsletters available in Hypertext

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The Reipurth *Herbig-Haro Object Catalog* and the *Star Formation Newsletters* are now available in hypertext versions on the University of Massachusetts Astronomy World Wide Web Server. The catalog can be used in the standard manner by scanning the pages using the vertical scrollbar. The object number is linked to the note for that object. If the suspected source is also in the HBC, it is linked to the entry there. The references are linked to the entry in the list of references. If possible, those references are linked to the ADS Abstract server. Because so many references are very recent, I placed all issues of the *Star Formation Newsletter* on line in hypertext also, to provide the recent abstracts. There were approximately 25 references to papers between 1890 and 1960. Abstracts, first pages, or, in a few cases, the entire reference was obtained and placed on-line, linked to the reference list. We plan to update the references to these papers as they are published. A table of contents has been supplied for each issues, as well as a cumulative table of contents for ease in searches. These are linked directly to each abstract.

The URL for the home page of our server is:

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For the Reipurth Herbig-Haro Object Catalog:

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